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A TUTOR TO Astronomy & Geography,

OR,

The Use of the

Copernican Spheres;

In two Books.

The first being an Explanation of the Copernican Hypothesis and Spheres.

The second proving the Phœnomena salved by the Earths Motion, as well as by its supposed Stability; as appears by the Application of these Spheres to Problemes *Astronomical*, *Geographical*, *Nautical*, *Astrological*, *Gnomonical*, and *Trigonometrical*.

By JOSEPH MOXON, *Hydrographer to the Kings Most Excellent Majesty.*

LONDON,

Printed for *Joseph Moxon*, and sold at his Shop on *Ludgate-hill* neer *Fleet-bridge*, at the Signe of *Atlas*, 1665.

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To the Right Honourable,

WILLIAM *Viscount* BROUNCKAR,

President of the Royal Society of *London*, for Improving of Natural Knowledge, &c.

My LORD,

His Book of the Use of the Copernican Spheres, *I humbly Dedicate to Your Lordship: who being signally eminent for Virtuous Endowments, will, I hope, out of your abundance, pardon*

pardon my Preſumption, ſith it onely proceeds from a great deſire I have to ſerve Your Honour. In which hopes I aſſume the boldneſs to write my ſelf

Your *Lordſhips* moſt humble ſervant.

Joſeph Moxon.

To the READER.

He many enquiries I have had for *Copernican Spheres*, hath induced me at laſt to adventure upon the making them both General and Particular: The General for Demonſtration, and the Particular for Operation.

The Diameter of the Starry Orbs are 20 Inches; And the ſubſtance of the Circles repreſenting the Orbs, is partly Wood, and partly Braſs: The greater Orbs are Wood, and the leſſer Braſs. The wooden Orbs are firſt made into ſtraight thin Riglets curiouſly glewed cloſe upon one another till they become of a convenient thickneſs and ſufficient ſtrength; and afterwards by Art made into Circles and Orbs: which Circles thus made, do not warp or ſhrink, as other wooden Circles will; Becauſe the ſeveral Riglets binde one another from altering their exact ſhape: And therefore they are as good for uſe thus made, as if they were made of Mettal; Nay far more cheap and handy. For were a Sphere made of Braſs of 20 Inches Diameter, its price

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(to moſt) would be unacceptable, and its weight troubleſome. Theſe Orbs and Circles are afterwards clothed with Papers printed on Copper Plates, properly Engraved for the purpoſe. And laſtly, the whole is ſo ſet together, that with the help of Rundles and Wheels, with great eaſe and delight all doubts are cleared, and difficulties removed that may hinder the Solution of the Phœnomena by this Hypotheſis.

And for your further accommodation, Becauſe theſe Spheres were never made in *England* before for general ſale, and therefore much unknown; I have writ this Book of the Uſe of them; wherein I have endeavoured to ſpeak plain to every man's Capacity: And, that I might be the plainer, I have purpoſely elected moſt of the ſame Problemes and Examples, and as neer as I could, the ſame Terms I did in the Uſe of the Globes; judging it more eaſie for a Student to learn what he is ſomwhat familiar with, than to begin in ſuch manner and matter with which he is not at all acquainted. Farewell,

Joſeph Moxon.

The First Book,

Being a Relation of the

Copernican Systeme;

And

An Explanation of the GENERAL and PARTICULAR SPHERES, made according to that *Hypothesis*.

PRÆFACE.

COPERNICUS *considering the Defect of the* Ptolomean *Systeme, was desirous to know if among the Ancients any famous Philosopher admitted another Hypothesis: And when he found* Pythagoras *held an Annual Motion and Diurnal Revolution belong to the* Earth; *he duely examined the Opinion, and found it so Rational and Perfect, that himself became of the same Perswasion. Upon this, He revives the Hypothesis, and sets forth as it were a New Systeme of the Visible World.*

In this Syſteme is placed the Sun *in the Center of the Univerſe, making a Revolution about its own Center in almoſt a Moneths time; and about him move concentrically all the other Celeſtial Bodies, except the* Moon, *and the Concomitants of* Saturn *and* Jupiter; *Next about the* Sun *moves the Orb of* Mercury, *which performs a Revolution about the* Sun *in* 80 *dayes; Next about* Mercury *the Orb of* Venus, *performing its Revolution in nine moneths; Next about* Venus *the Orb of the* Earth *and* Moon, *moving about the* Sun *in one Year. The* Moon *being carried about the* Earth *as a Circle about its Center in* 28 *dayes; Next about the* Earth *the Orb of* Mars, *which moves about in two Years; Next about* Mars *the Orb of* Jupiter, *and his four Concomitants, in twelve Years; About* Jupiter *the Orb of* Saturn, *and his two Concomitants, in thirty Years: And all theſe Orbs are included and ſhut up within one Orb of the fixed* Stars; *which hath a common Center with all the other Orbs,* viz. *the* Sun, *through which Orb the Æquator revolves upon the Axis of the Ecliptick in* 25412 *Years: And for this cauſe this Starry Heaven was formerly thought to perform a Revolution in that ſpace of time.*

This Hypotheſis being look'd upon in Schools

as

as a Novel Intruſion, hath found much oppoſition: Nor is it a wonder; for Ptolomy's *Syſteme having for a long time been read to young Pupils, and ſeeming plauſible to Sence, and pleaſing to Fancy; hath gained ſo much favour, and ſuch a general acceptance, that as at firſt it was their Task to ſtudy his Theory, afterwards they thought it their Duty and Intereſt to defend their Practiſe, by eſpouſing a Controverſie againſt the* Copernicans.

Copernicus *himſelf hath learnedly defended this Hypotheſis: And ſince him, ſeveral other Learned Judicious and Serious Perſons have done the like: And among the reſt,* Galilæus, *whoſe curious ſcrutiny in Cœleſtial Speculations, hath with his Teleſcopes diſcovered ſuch wonderful Appearances among the Heavens to confirm this Hypotheſis, that who ſo liſts but to peruſe his* Dialogues *upon the Syſteme of the World, ſhall therein finde ſuch pure Reaſon, and concluding Arguments, that undoubtedly he ſhall cloſe with this Opinion.*

Now though my Intenſions be only to write the uſe of theſe material Spheres, and not to defend the Syſteme; for that were an endeavour (as the Vulgar Proverb ſayes) to add light to the Sun by ſetting up a Candle; yet I think it proper in

this place to inſert ſome of the ſtrongeſt Arguments the Ptolomeans *bring againſt this Hypotheſis; and alſo the Anſwers the* Copernicans *give unto them.*

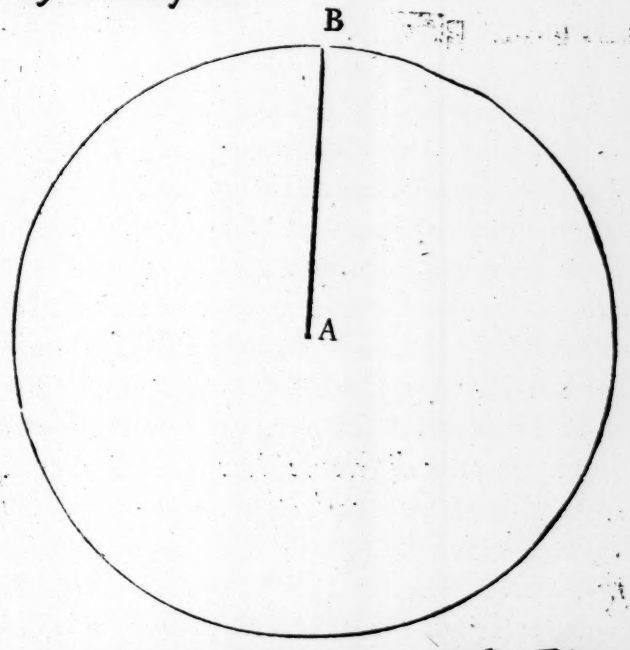
ARGUM. 1. *Is againſt the Motion of the Earth: For, ſay they,* We ſee the Sun, Moon, and Stars riſe in the Eaſt, make a progreſs through the South, and ſet in the Weſt. Therefore our Viſual Senſe demonſtrates they move, not we.

In anſwer to this we may urge, That the Senſe of Seeing is deceitful, and makes that ſeem to move which ſtands ſtill; and that ſtand ſtill which moves: as is often ſeen upon the Water: For Rowing in a Boat, the Boat ſhall ſeem to lie ſtill in the Water, and the Banks of the Shore ſhall ſeem to ſlide away from us: And many times the Moon *and* Stars *ſhall ſeem to go along with us which way ſoever we go.*

ARGUM. 2. Looking round about us, the Heavens appear on each quarter exactly equi-diſtant from us: Therefore the Earth is in the Center of all the Heavens: For, were it in any other place, we ſhould perceive one part of Heaven neerer to us than another: and the Stars would ſhew greater on that part of Heaven, which ſhews neereſt to us, and

and leſſer in that part of Heaven which ſhews fartheſt from us.

Anſw. *The diſtance of the Starry Heaven from the* Sun, *which is the Center of the Starry Heaven, is ſo vaſt, and the diſtance of the Earths Orb ſo ſmall, that it ſeems in the very Center it ſelf, and therefore makes in the ſight no alteration: as by this following Scheme and Example may be underſtood.*



Imagine this Circle were 20 *Inches Diameter, and it repreſented the Starry Heaven:* A *is the*

the Center of this Circle; which is on all parts equi-diſtant from the Circumference. The Line A B *(its half Diameter) will then be* 10 *inches long. Now ſuppoſe this Line were divided into* 6875 *equal parts (for the Semi-diameter of the Starry Heavens contains the Semi-diameter of the Earths Orb* 6875 *times) and that the Center were removed from its true place one of thoſe equal parts: Then may you firſt conſider the apparent length of one of thoſe parts; and ſecondly, what difference in appearance from the Center it would have. If the whole length* 10 *inches be divided into* 6875 *equal parts, then ſhall every inch be divided into* 687 *parts, which is ſo ſmall a length, that it exceeds not half the bredth of an hair on a mans head, according to a tryal I have made for that purpoſe: And what difference at the Circumference half a hairs bredth will make from the true Center of a Circle of* 20 *inches Diameter, is to be conſidered. It is true, it is a difference from the true Center, but a difference ſo ſmall, that no man with the Point of a Needle can make a perceptible mark of that ſize.*

Now though the diſtance of the Earths Orb from the Center of the Starry Heaven be ſo ſmall that it is ſcarce diſcernable by reaſon of the vaſt diſtance

diſtance of the ſtarry Heaven, yet the diſtance of the Earths *Orb from the Orbs of* Mars *and* Venus *is not ſo great, but that a ſenſible difference appears at ſeveral times in the ſight of theſe Planets: For* Mars *in his* Perigeum, *that is, when he is neereſt to the Earth, appears ſixty times bigger than in his* Apogeum, *which is his greateſt diſtance from the Earth: And* Venus *in her* Perigeum *appears forty times bigger than in her* Apogeum; *As with the* Teleſcope *hath been obſerved by* Galilæus, *and others.*

Argum. 3. It is againſt Reaſon to think the Earth ſhould turn round; For then we ſhould every Converſion have our Feet turned upwards, and our Heads hanging downwards in the Ayr; Our Houſes would tumble over; and every looſe thing, as Stones, Animals, &c. fall from the Earth, as having nothing to reſt their Weight upon.

Anſw. *It is unreaſonable to think Nature ſhould Create any thing to its own Deſtruction; which we muſt allow, in caſe the place aſſigned it by Nature be not apt enough to retain it: for nothing can ſubſiſt without a proper place: But we ſee it cuſtomary with Nature to Act beyond Vulgar Reaſon: For, whether the Earth turn round,*

round, or ſtands fixt in the Center, it matters not in this Argument: For we all allow the Earth to be round, and few men now are ſo unskilful in the ſhape of the Earth, *as with* Lactantius, *to deny an* Antipodes *to every place on the Earth; which* Antipodes, *according to the reaſon of this Argument, is as much ſubject to theſe Caſualties as the whole Earth in its Converſion. Nay, the whole Earth by admitting* Antipodes, *runs equal hazard of dropping all looſe things into the Ayr, as admitting of the Earths Converſion does.*

Argum. 4. If according to the *Copernican* Doctrine the Earth move round from *Weſt* to *Eaſt* in 24 hours, then admitting the Circumference of the Earth to be 21600 miles, it muſt in one hour move 900 miles, and in a minute 15 miles, and in the fifth part of a minute 3 miles; ſo that if a Stone be let fall from an high Steeple, and it be the fifth part of a minute in time falling, which it may be from ſeveral Steeples in *London*, by that time the Stone comes to the ground, the Earth ſhall have paſſed from *Weſt* to *Eaſt* 3 miles; and the Stone muſt by conſequence fall 3 miles to the Weſtwards of the bottom of the Steeple. To this Argument may be added,

added, that Pidgeons may by ſtrength of their Wings fly three miles to the Weſtwards from their Dove-houſe in one quarter of an hour: But in this time ſhould the Dove-houſe by the Earths motion be preceded Eaſtwards 225 miles, which with the acquired motion of three miles, makes 228 miles; and then they ſhould alight 228 miles off their Dove-houſe. Both which Arguments, and ſeveral other of the ſame Nature, Experience contradicts: Therefore the Earth ſtands ſtill.

Anſw. *By the Earth is not meant only this bare Ball of Earth and Water whereon we inhabite; but the whole Body, as it is clothed with the Elements of Ayr and Fire: For theſe Elements are frequently convertible into each other: And, as Philoſophers teach us, are never ſo purely one as not to have a mixture of all: Therefore what ever is within this Sphere of Elements, we ſay is in the Earth, though part of theſe Elements for their purity be elevated above the Surface of that Soil whereon we go. And therefore when we ſay the Earth moves, we do not mean onely that part of the Elementary Sphere which we call Earth; But by the Earth we mean the whole Body of Elements, which is*

according to this Doctrine agitated by one ſingle activity; and what moves in any part of this Sphere, moves in all: As for Example; The Stone and the Doves being Elementary Bodies, are incloſed within the Sphere of the Earths Activity, viz. *within the Ayr at the higheſt; and therefore have the Motion impreſt upon them that the Earth hath: For which way ſoever the Stone falls, or is thrown; or which way ſoever the Pidgeon flies, they move along Eaſtwards with the Earth, though they fly Weſtwards. Thus Experience ſhews, that if a Ship Sails in a ſwift Motion Weſtwards, it may in one Second of Time run about three Yards; And if one let fall a Stone from on high into the Hold, that Stone ſhall not fall three Yards Eaſtwards from the Perpendicular Point, but juſt upon the ſame Point in the Bottome of the Hold it would have fallen if the Ship had layn ſtill,* viz. *on the Point Perpendicular to the Point above it from whence it was let fall: When as if the Stone had not received the impreſt Motion of the Ship, it muſt have fallen three Yards to the Eaſtwards of that Point.*

Argum. 5. The Earth is a heavie Body, and therefore unfit for Motion, eſpecially through the pure Heavens; for ſuch is the

the ſublimity of them, that the weight of the Earth would preſs through them; and ſo it ſhould loſe its place.

Anſw. *If the Earth be a Heavie Body, yet it is not unfit for Motion, if the moving Power be ſtrong enough to ſet it going: But heavie Bodies are more unfit to lye ſtill in the ſublime Heavens, than to move in them. For thus we ſhall ſee a Stone thrown into the Ayr, while it has motion it will abide there; but when the Motion dies, the Stone falls.*

Thus briefly have you heard Ptolomy *Plaintiff, and* Copernicus *Defendant (pardon theſe Law phraſes) And you have heard the chiefeſt Natural Arguments and Anſwers on either ſide. The Cauſe is referr'd to your own Judgements.*

Copernicus *alſo has a Plaint againſt* Ptolomy, *and brings good Evidence that he traduces the whole Syſteme of the World, makes it monſtrous, prepoſterous, deficient, abſurd, irregular, unnatural; and in a word, compounded of incongruities: His Witneſſes are Sence, Reaſon, Experiment, and Demonſtration: He onely deſires an Intelligible Judge, and doubts not but he ſhall caſt* Ptolomy. *Yet ſuch as are deſirous to know what he has to plead, may peruſe Himſelf,* Kepler, Bulialdus, Lansbergius, Galilæus, Helvetius, *&c.*

But Copernicus *has not quite cleer'd himſelf; He muſt anſwer another ſort of Antagoniſts: For as of old this Hypotheſis was condemned by the Religious men of thoſe Times, who thought it Blaſphemy againſt the Goddeſs* Veſta *to deny her the Attribute of Stability; ſo now many reject it, becauſe they think it againſt the Doctrine of our Religion; and plead ſeveral places of Holy*

Object. 1. *Writ againſt this Opinion. And firſt, to prove the Earths ſtability, they object that in* Pſal. 104. 5. He ſet the Earth upon her Foundations, ſo that it ſhall never move: *And in* Pſal. 24. 2. He hath founded it upon the Seas, and eſtabliſhed it upon the Floods: *with ſeveral other places of the like ſence.*

Anſw. *There is nothing in theſe Scriptures againſt the Motion of the Globe of Earth; but enough to enſure us that the Element of the Earth, I mean the Land, ſhall never move out of the place God hath aſſigned it: Becauſe it hath its Foundation on the Seas, and there it is eſtabliſhed: For neither doth the Pſalmiſt, or any other holy Writer deny, that as it is a Globe, it hath a Motion: But they ſay, as it is a ſolid Subſtance, and Land, it hath its Foundations,* &c. *And it is plain the Spirit of God in thoſe Texts means the Land, and not the whole Ball Aſtronomers call Earth,*

Earth, which conſiſts both of Earth, Water, &c. *for* Moſes *tells us* Gen. 1.10. *that* God called the dry Land Earth.

Secondly, *To prove the Motion of the Sun,* Object. 2. *they quote* Eccleſ. 1.5. *where it is written,* The Sun Riſeth, and the Sun goeth down, and draweth to the place where he Riſeth: Pſal. 19.5,6. *where the Pſalmiſt ſpeaking of the Sun, ſaith,* Which cometh forth as a Bridegroom out of his Chamber, and rejoyceth as a mighty man to run his Race: His going out is from the end of the Heaven, and his Compaſs is unto the ends of the ſame: *with ſeveral others to the ſame purpoſe.*

Anſw. *We muſt not think it the intent of the Spirit of God in theſe places, or ſeveral other, to teach us the Regiment of the Sun; But to ſet us admiring the Works of the Creation, that ſo we might be the apter to glorifie him: And to this purpoſe his Pen-men knew it as advantagious to ſay the Sun Riſes and Sets, as to ſay the Earth turns about; for it ſhews equal Power in the Creator, to Ordain the Sun a Motion about the Earth, as to give the Earth a Motion about the Sun. But it better fitted the purpoſe of thoſe Holy Scribes, for that they in the whole Current of Sacred Scripture writ to the Vulgar Capacities*

of

of every man; and therefore chose a plain and familiar Dialect: For thus they frequently represent to us God, as Man, speaking as if his Body were composed of Members, viz. Hands, Arms, Eyes, Ears, *&c. And his Mind addicted to Passions, as* Anger, Mirth, Sorrow, *&c. Not that he is composed of Members, for they knew he is a Spirit; or that he is subject to Passions, for they knew that he is unchangeable, one and the same for ever: But that they might suit their Divine Discourses to Humane Understanding, they tell us Mortals, how God sees and hears all our works and words, as if he had* Eyes *and* Ears: *And that Himself will give Reward or Punishment, as if he had* Hands *and* Arms, *&c. And that all the Decrees of God, whether Blessings for good Works, or Curses for wicked Works, shall as unavoidably come upon the Godly and the Wicked in due time, as if a Formal Process should gradually prepare the Execution.*

Besides, to our sensual appearance the Sun doth Rise and Set, and should the Spirit of God have said the Earth turns about, it might so have confounded Vulgar Understandings, that the Praises, Glory and Honour due unto God, might have been neglected through the Unbelief of that Truth which seems so improbable to our Sense of Seeing. But

But in brief, As to theſe Texts, or any other Text in that Sacred Volumn, Take this pithy Anſwer of St Auguſtine, *quoted by* Galilæus, *and thus Engliſhed by* Mr Salusbury: If any one ſhall object the Authority of Sacred Writ againſt clear and manifeſt Reaſon, He that doth ſo, knows not what he undertakes; for he objects againſt the Truth, not the Sence of the Scripture, which is beyond his comprehenſion: Not what is in it, But what finding it in himſelf he fancied to be in it.

Thus have I done with theſe Natural and Divine Arguments; I come now to my Primitive Intentions which is, to ſhew you that Spheres thus made will anſwer the Appearances of Heaven as well as the Ptolomaick *Spheres do: And in Order thereunto, I Preſent you with Material Spheres, made according to this* Hypotheſis; *And herein I ſhall firſt Explain every Part and Lineament in them: And afterwards ſhew you how to apply them to all the Uſes the* Ptolomaick *Sphere or Globe is to be applyed.*

CHAP.

Chap. I.

What a Sphere is.

IN the uſe of the Globes I told you, that a Globe was a perfect round Body, contained under one ſuperficies; and a Sphere in a Geometrical Denomination, is the ſame with a Globe, and is by Mathematicians indifferently called either Globe or Sphere. But though a Globe or Sphere is, in reſpect of a Geometrical Body, one and the ſame, yet as they are both Aſtronomical Inſtruments, there is difference between them. For thus a Globe is an intire whole Body, but a Sphere is fabricated of ſeveral Lath-like Circles, ſo fitted together, that it only ſerves to repreſent a whole Body or Orb to the fancy. And the Reaſon why theſe Spheres are made of ſeveral Circles is, becauſe the whole Syſteme of the World conſiſts of ſeveral Orbs, the one placed within another; And ſhould any of theſe Orbs be made of one intire and whole Superficies, unleſs it were of a tranſparent matter, it would obſcure all the other Orbs within it.

Of theſe Spheres there are chiefly two ſorts invented, the one the *Ptolomaick* Sphere, and the other the *Copernican* Sphere.

The *Copernican* Sphere is the Subject of this Diſcourſe,

courſe, and is made two ſeveral wayes, *viz. General* and *Particular*: The *General* is (as it were) a Model of the whole viſible World, containing the Starry Heaven, the Planets, their Orbs, Orders and Motions about the Sun. So that this Sphere is moſt apt for Demonſtration of this *Hypotheſis*.

The *Particular Sphere* repreſents the Sun in the Center of the Starry Heaven, and hath only the Earth moving about it; But is ſo accommodated with ſeveral Circles, that by it may be performed all Queſtions relating to the Sphere. I intend firſt to treat of the General Sphere; which that you may the better underſtand, I ſhall in the next Chapter deſcribe its Parts.

Chap. II.

Of the Parts of the General Sphere.

The Sun.

In the Center of this Sphere is placed a little Golden Ball, which repreſents the Sun; from the *Zenith* and *Nadir* of this Ball runs a Wyer, upwards and downwards, through all the Orbs of this Sphere, and holds them all together at their proper diſtance from the Sun: This Wyer repreſents the Axis of the Ecliptick: The upper end of it is called the *North Pole*, the lower end the *South Pole*.

Axis of the Ecliptick.
North Pole.
South Pole.

Next about the Sun is placed the Orb of *Mercury*, and is repreſented by three Circles; two of them ſtand upwards and downwards, and cut each other at right Angles in the Axis of the Ecliptick; The other Circle cuts them both, and is cut by them both at right Angles in the Plain of the Ecliptick: In the middle of one of the quarters of this Circle ſtands a ſmall round Ball which repreſents *Mercury*, who performs

Orb of Mercury.

his motion through all the Signs of the Ecliptick in 80 dayes.

Orb of Venus. Next about *Mercury* is placed the Orb of *Venus*, and is also represented by three Circles, as before is said of *Mercuries* Orb. She performs her motion through all the Signs of the Ecliptick in 9 Months.

Orb of the Earth. Next about *Venus* is placed the Orb of the Earth, and is also represented by three Circles, as before is said of *Mercury* and *Venus*. It is subject to a two-fold motion, besides an *Inclination* formerly called a *Motion*.

The Earth Subject to a twofold motion, besides an Inclination. *The first motion called the Diurnal motion.* The first motion is performed upon its own Axis, from West to East in 24 hours, and is called the *Diurnal Revolution*: because its turning to the Sun makes Day, and its turning from the Sun makes Night.

The second motion called its Annual motion. Its second motion is its progress through the Signs of the Zodiack, which it performs in 365 dayes: and is therefore called its *Annual Motion*.

Its Inclination. Its Inclination shews how the Poles of the Earth always incline to the same quarter of Heaven, (even as a Needle toucht with a Load-stone doth) and keeps the Axis of the Earth always and in every Degree of the Zodiack parallel to it self. By this Inclination the Seasons of the year are altered; And the Dayes and Nights increase and are diminished.

Orb of the Moon. About the Earth moves the Orb of the Moon, and finishes her course about the Earth in 29 dayes: And though to our apprehensions she seems to run through all the Signs of the Zodiack in that space of time, yet she being carryed about with the Earth, takes up about the same time to run through all the Signs of the Zodiack the Earth doth, *viz.* 365 dayes: as shall be shewed here-after.

Orb of Mars. Next about the Orb of the Earth and Moon, is placed the Orb of *Mars*, and is also represented by three

three Circles, as before is ſaid of the reſt. He finiſhes his motion through all the Signs of the *Zodiack* in two years.

Next about the Orb of *Mars* is placed the Orb of *Jupiter*, and is repreſented by three Circles as before. He finiſhes his motion through the Ecliptick in twelve years. *Orb of Jupiter.*

Next about the Orb of *Jupiter* is placed the Orb of *Saturn*, and is repreſented by three Cricles as before; He finiſhes his motion in 32 years. *Orb of Saturn.*

About all theſe Orbs is framed the Orb of the Starry Heaven, repreſented by four Circles; two of theſe Circles ſtand directly upwards and downwards, and croſs each other at right Angles in the Poles of the Ecliptick: Theſe two Circles are called *Colures*. That which paſſes through the Equinoctial Signs of *Aries* and *Libra*, is called the *Equinoctial Colure*; And that which paſſes through the Tropical Signs of *Cancer* and *Capricorn*, is called the *Tropical Colure*. The firſt of theſe Colures, *viz.* that which paſſes through *Aries* and *Libra*, is divided from the middle points between the two Poles both wayes into 90 degrees; ſo that the whole is divided into four times 90 degrees, and numbred from the middle point into each Pole, with 10, 20, 30. to 90. *Orb of the Starry Heaven.*

Theſe two Colures divide the Heavens into four equal parts, which are called *Solſtices*; The firſt is a Semi-circle, which paſſes from the Poles of the Ecliptick through the begining of *Aries*, and is called the *Autumnal Solſtice*. The ſecond is that Semi-circle which paſſes from the Poles of the Ecliptick through the begining of *Cancer*, and is called the *Hyemnal Solſtice*. The third paſſes through the begining of *Libra*, and is called the *Vernal Solſtice*. The fourth *Solſtices.*

through the begining of *Capricorn*, and is called the *Eſtival Solſtice*.

The progreſs of the Earth through theſe Solſtices, alter the ſeaſon of the Year; for when the Earth enters the Autumnal Solſtice Autumn begins; and when it enters the Hyemnal Solſtice Winter begins; when it enters the Vernal Solſtice Spring begins; and when it enters the Eſtival Solſtice Summer begins.

Zodiack. Theſe two Colures are cut in the middle at right Angles by a broad Circle, repreſenting the *Zodiack*. In the middle of this *Zodiack*, on the in-ſide is a circle deſcribed, which is divided into 12. equal parts, called *Signs*; The firſt of theſe Signs begins at the Autumnal Colure, and is called *ARIES*, wherein is figured the Picture of a Ram. The ſecond Sign is called *TAURUS*, wherein is figured the Picture of a Bull. The third *GEMINI*; and ſo ſucceſſively to *PISCES*, with the proper Pictures in each ſign. Theſe Signs are each divided into 30 degrees, and numbred at each tenth with 10, 20, 30.

Theſe three great Circles are cut obliquely by another great Circle, and makes an Angle with the Ecliptick of 23 ½ degrees, which repreſents the Equinoctial: Which is a narrow Circle, and is divided on the in-ſide into 360 degrees, and numbred from the begining of *Aries* towards *Taurus* with 10, 20, 30. to 360.

Equinoctial.

Upon theſe four great Circles are pictured many Stars, that ſo the whole Orb may more plainly repreſent the Starry Heaven.

Axis of the Equator. Twenty three and an half degrees from each Pole of the Ecliptick is fixed upon the Tropical Colure, two ſmall ſhort Wyers oppoſite to each other, which repreſents the Axis of the Equator.

Theſe Orbs thus joyned together, are ſo fitted upon

on a Pedeſtal, with a handle to it, that the Axis of the Ecliptick ſtands directly upwards, cutting the plain of the Ecliptick at right Angles, and paſſing through the Center of each Orb, and alſo keeping them at their proper diſtances.

Yet muſt we grant that the Diameter of their Orbs and their diſtances from each other, cannot be truly proportioned in theſe material Spheres. For the whole Diameter of the Starry Heaven in theſe Spheres are but about 20 Inches: And could we make the Orb of the Earth ſo ſmall that it ſhould bear its true proportion to this Starry Heaven, the Diameter of the Earths Orb ſhould be but the 687th. part of an Inch: that is, if you divide an Inch into 687 equal parts, the Diameter of the Earths Orb ſhall be but one of thoſe parts; as was ſaid in the *Preface*.

This proportion may be thought fabulous by ſuch as are not much read in Aſtronomy; eſpecially if they ſhall conſider that it is the Diameter of the Earths Orb: That is, the Circle wherein the Earth moves, and that within it are included the Orbs of the *Moon*, *Venus*, *Mercury*, and the Body of the Sun, and alſo the Earthly Globe it ſelf; which alone is accounted to be in Diameter 6870. Miles, and yet is but inconſiderable, and as a point to the Earths Orb, as is the Earths Orb to the Starry Heaven; And therefore juſtly may the Ancients have accounted the Earth, but as a point compared to the whole Fabrick of the Viſible World.

This is the frame of the *Copernican* Syſteme: And this Frame will ſufficiently ſerve to repreſent the Order and Motion of the ſeveral Orbs. But notwithſtanding the Earth in this Sphere is made ſo much too big for the Heavens, yet is it ſo ſmall, that what concerns

moſt Problems in *Aſtronomy* and *Geography*, cannot be anſwered thereby: neither can ſuch proper Circles be applyed thereto, as ſhall be requiſite to demonſtrate their operation.

For this cauſe hath *G. Cæſius* contrived how by the leaving out the Orbs of all the Planets, except the Earth, (as unmaterial) to make the Earth ſo large, and to furniſh it with ſuch apt Circles, as that by his Invention may be reſolved all manner of *Aſtronomical* and *Geographical* Queſtions by this *Copernican* Sphere, as well as by the Common Celeſtial and Terreſtrial Globes.

But becauſe this Sphere differs in faſhion from the Sphere I have juſt now deſcribed; I ſhall in the next Chapter explain the ſeveral parts of it, and afterwards ſhew how it may be applyed to the ſeveral Uſes the Celeſtial and Terreſtrial Globes are.

Chap. III.

An Explanation of the ſeveral Parts of the Particular Sphere.

THis Fabrick ſtands upon four ſmall wooden Feet, and upon theſe feet are fixed the ends of a wooden Croſs; upon this Croſs is faſtned a large hollow wooden Circle, whoſe outmoſt and inmoſt limb lies on all ſides equidiſtant from the Center of the Croſs; ſo that the Center of the Croſs is common to the Center of the wooden Circle. On the upper plain of this Circle is deſcribed two *Calenders*; the one the Old-ſtile uſed by us in *England*, *Scotland* and *Ireland*; the other the New-ſtile uſed in moſt other Chriſtian Places

Calender of the Old ſtile.
Calender of the New ſtile

Places beyond the Seas. Each of the Months hath its name affixed to it: and each black or white Diviſion ſignifies one Day, and every tenth Day is numbred at 10, 20, or 30, *&c.*

That Calender next the outmoſt verge, is the New-ſtile, and that next the innermoſt verge is the Old-ſtile; and for ornament ſake, is adorned with the Pictures of all the twelve Months of the Year. *New ſtile. Old ſtile.*

Between theſe two Calenders, is placed a Circle of the twelve Signs of the Zodiack; And to each Sign its Character and name affixed. As to *Aries*, the Character ♈ and the word *ARIES*. To *Taurus*, the Character ♉ and the word *TAURUS*. And ſo all the reſt: Each of theſe Signs is divided into 30. degrees, and numbred with 10, 20, 30. *Circle of Signs.*

Cloſe within the inſide of this wooden Circle, is fitted a flat moveable Rundle, whoſe Center is the ſame with the common Center. *Moveable Rundle.*

On the upper plain of this Rundle is ſometimes paſted a Projecton of the Stars and Conſtellations about the North Pole; or elſe ſome other projection that may better pleaſe the fancy; for it is not of any concernment, more than to cloath that naked plain.

The outmoſt Verge of this moveable Rundle is divided into 24 equal parts, repreſenting the 24 Hours of Day and Night, numbred from the Index towards the right hand, with Numeral Letters thus, I II III IIII V, *&c.* to XII, and then begining again with I II, *&c.* till it end with XII again.

About the Center of the Croſs, under this wooden Rundle, is faſtned a round Wheel, whoſe outmoſt Verge is cut into a certain number of Teeth, like thoſe of a Wheel of a Clock: This Wheel lies fixt upon the Croſs and moves not.

Through

Through the wooden Rundle, the Wheel on the Croſs, and the Croſs it ſelf is fitted a Perpendicular Axis whereon the Rundle moves as upon a Center. This Axis repreſents part of the Eclipticks Axis; and at the top of it is placed a little golden Ball, which repreſents the Sun.

Axis of the Ecliptick.

The Sun.

On the under ſide of the wooden Rundle moves another Wheel, whoſe outmoſt Verge is made with Teeth; and as the Rundle is turned about upon its own Center, this Wheel is alſo turned about upon its Center, by the falling in of the Teeth on that Wheel fixed on the Croſs.

Neer the outmoſt Limb of the Rundle, is fitted another Wheel, and into this Wheel is fitted a Pedeſtal, which holds up a Sphere of ſeveral Parts, wherein a Terreſtial Globe is incloſed, as ſhall be ſhewed hereafter. The outmoſt Limb of this Wheel is alſo cut into Teeth; and by the agitation of the two other Wheels, this Wheel is carried about, and with it carries about the Earth, and all the Circles faſtned upon the aforeſaid Pedeſtal.

On one ſide of this Rundle is faſtned a little round Pin to turn about the Rundle by, and near to this Pin upon the Rundle, is made an Index which reaches to the outmoſt Verge of the great hollow wooden Circle, and ſo at once is applyed to the day in the Month in both Calenders, and alſo to the degree of the Ecliptick the Sun is in that day; This Index is called the *Index of the moveable Rundle.*

Index of the moveable Rundle.

On each end of the Croſſes aforeſaid, is placed a Pillar or Column, which ſerves to ſupport a great wooden Circle repreſenting the Zodiack of the eighth Heaven; in the middle of which on the inſide runs a double Line quite round about the whole Circle, which

Zodiack.

which is divided into twelve Signs, and are called, *The Signs of the Zodiack*; each of which Sign is represented by its proper Character, Figure and Name; As to the Sign *Artes*, is set the Character, ♈, the picture of a *Ram*, and the word *ARIES*. To *Taurus* the Character, ♉, the picture of a *Bull*, and the word *TAURUS*, and so for all the rest. Each of these Signs is divided into 30 Degrees, and numbred at each tenth, with 10, 20, 30. This great limb is called the *Zodiack* throughout this Book; and by that name is distinguished from another Circle very like this, called the *Ecliptick*.

Upon the *Pedestal* that is placed near the outmost limb of the Rundle, is fastned two pretty strong wooden Circles, which cut each other at right Angles: These Circles represent the two Colures, and are placed so, that the points where they intersect each other, stand directly upwards and downwards, and represent the Poles of the *Ecliptick*; the uppermost Point represents the North Pole, the undermost the South Pole. One of these Colures is called the *Equinoctial Colure*; viz. that which passes through the *Equinoctial* Signs of *Aries* and *Libra*: The other the *Tropical Colure*; viz. that which passes through the *Tropical* Signs of *Cancer* and *Capricorn*: And this Colure is on the outside divided into 360 Degrees, or which is all one, into four nineties, beginning in the middle between the two Poles; *viz.* in the plain of the Ecliptick, and so numbred each way, with 10, 20, 30, to 90, which is in the Pole of the Ecliptick. On this Colure is placed a small Hour-Circle about the *Axis* of the Earth, divided into 24 equal parts, which represent the 24 hours of the day and night, and numbred with numeral letters, thus, I, II, III, IIII, V. to XII;

Colures.

Poles of the Ecliptick.

Equinoctial Colure.

Tropical Colure.

XII; and then begining again with I, II, III, &c. to XII; till you come to the point where you first began.

Ecliptick. In the middle between the two Poles, is fitted another Circle, which represents the Ecliptick, a good deal broader than the Colures; it cuts the Colures at right Angles, and is by the Colures divided into four quarters; *viz.* in ♈ ♋ ♎ and ♑: each of these quarters are divided into three equal parts, which are called *Signs*, and each of the Signs noted by its proper name, picture and character; as to the Sign *Aries*, the word *Aries*, the picture of a *Ram*, and the character ♈; to *Taurus* the like, and so for all the rest: Each of these Signs is divided into 30 Degrees, marked at 10, 20, 30.

On the inner edge of this Ecliptick, is placed several of the most notable fixed Stars, with their names affixed to them, and each Star placed to the degree and minute of Longitude thereon, that it hath in Heaven from the Equinoctial point *Aries*.

Equinoctial. Oblique to this Ecliptick 23 ½ degrees on the inside is fitted a thin Circle, representing the Equinoctial; It cuts one Colure in the points of *Cancer* and *Capricorn*, and the other Colour, together with the Ecliptick in the Points of *Aries* and *Libra*; it is divided into 360 Degrees, and numbred from the Equinoctial Point, *Aries*, with 10, 20, 30, to 360.

Tropicks. Parallel to the Equinoctial at 23 ½ Degrees distance on either side are fitted two smaller Circles, representing the Tropicks; that on the North side the Equinoctial, represents the Tropick of *Cancer*; that on the South side the Equinoctial, represents the Tropick of *Capricorn*.

On the inside all these Circles in the Poles of the Ecliptick, is fitted two thin semi-Circles (called, *Semi-Circles*

mi-Circles of Latitude) ſo as one of them may move through one half the Ecliptick; *viz.* from *Cancer* through *Aries* to *Capricorn*; and the other from *Cancer* through *Libra* to *Capricorn*. Theſe two Semi-Circles of Latitude, may be diſtinguiſhed one from another, by calling the firſt of them, *The Vernal Semi-Circle of Latitude*; becauſe it paſſes through the Vernal Sign, ♈, and the three Signs on each ſide of it; and the other the *Autumnal Semi-Circle of Latitude*, becauſe it paſſes through the Autumnal Sign ♎, and the three Signs on each ſide of it; ſo that theſe Autumnal Signs lying in the middle of the progreſs of theſe Semi-Circles of Latitude, may properly give a name to each Semi-Circle. *Semi-Circles of Latitude.*

At the edge of theſe Circles, are depicted the ſame fixed Stars in their proper Latitude, from the Ecliptick Line, that are placed on the Ecliptick Circle aforeſaid, with their ſeveral names affixed to them.

Through the Solſtitial Colure at 23½ Degrees from each Pole of the Ecliptick, paſſes a Wyer, which repreſents the Axis of the Earth. On the Northern end of this Axis, is fitted an Index, which ſerves to point at every hour on an Hour-Circle, which is fitted on the Solſticial Colure, as aforeſaid. *Axis of the Earth.*

In the middle of this Axis, between the two Poles of the Ecliptick, is fixed a great round Ball, which repreſents the Earth, having the bounds of the Lands and Waters depicted thereon, and alſo the Names of ſo many Countries and Towns, as can conveniently be placed on a Globe of that Dimenſion. *The Earth.*

In two Points of the Equinoctial of this Globe, *viz.* at 90 degrees Eaſtwards from the firſt *Meridian*; and in its oppoſit Point, *viz.* at 90 degrees Weſtwards, are fixed two ſmall Pins, whereon a movable *Horizon* *Horizon.*

is placed in the Eaſt and Weſt Points thereof, ſo as thoſe Pins ſerve for an Axis to the *Horizon*; for on thoſe Pins the *Horizon* may be elevated or depreſſed to any degree the Pole is elevated above the *Horizon*.

Circle of Degrees. The outmoſt Limb of this *Horizon* is divided into twice 180 degrees, beginning in the South Point, and reckoning both Eaſtwards and Weſtwards to the North Point, with 10, 20, 30, to 180 degrees.

Mariners Compaſs. The two next Circles within that Circle of degrees, ſhew the thirty two Winds of the Mariners Compaſs, each Point of the Compaſs having its name affixed to it.

Antient Winds. Next within thoſe Circles is a Circle divided into twelve equal parts, according to the manner of the Antients, having the name of each Wind affixed to it, as they were named by them: and in the ſpace between this Circle and the Earth, is emblematically expreſſed the natural quality of each of theſe Winds.

Meridian. This *Horizon* ſlides on the North and South Points, within a broad Brazen *Meridian*, hung upon the Axis of the Earth: This Brazen *Meridian* is divided into 360 degrees, and numbred from the North Pole either way, with 10, 20, 30, to 90 in the Equator; from whence on either ſide on the *Meridian* is numbred 10, 20, 30, till it end at 90 in the South Pole.

Round about this Brazen *Meridian*, on the outmoſt ſide, is made a Grove, into which is fitted a ſmall braſs Ring, ſo as the upper ſide of it lies even with the upper ſide of the brazen *Meridian*; this ſmall braſs Ring is faſtned to two oppoſite Points in the *Horizon*, viz. in the North and South, and ſerves as a ſpring to keep it to that degree of the *Meridian* you elevate the *Horizon* to.

Upon two Pins on this ſmall Ring, is alſo faſtned

two

two Semi-Circles of Altitude, or Vertical Circles, yet not ſo faſtned, but that they may move as upon Centers, the one moving from the North to the South through the Eaſtern ſide the *Horizon*; the other moving from the North to the South, through the Weſtern ſide the *Horizon*. This motion is performed upon the two Pins aforeſaid, as upon two Poles, which indeed they ſerve to repreſent (for they repreſent the Poles of the *Horizon*) and therefore are ſo placed, that they may divide the upper and under half the *Horizon*, into two equal parts, and as the *Horizon* is moved, ſlide alwayes into the *Zenith* and *Nadir*, and ſo become the Poles of the *Horizon*.

Vertical Circles.

Poles of Horizon; viz. *Zenith and Nadir.*

Theſe two Semi-Circles of Altitude, are divided each into twice 90 degrees, numbred at the *Horizon* upwards and downwards, with 10, 20, 30, and ending at 90 in the *Zenith* and *Nadir*.

I have already declared the ſeveral Uſes of each particular Circle herein mentioned in the uſe of the Globes; whither for brevities ſake I refer you, they being with the Globes and Spheres of the ſame uſe; and therefore need no further Comments upon them in this place.

The End of the Firſt Book.

The Second BOOK:

Being the Practical Uſe of the

Copernican Spheres,

Applying them to the Solution of

PROBLEMES Aſtronomical, Geographical, Nautical, Aſtrological, Gnomonical, and Trigonometrical.

PRÆFACE.

FOr the better underſtanding the Uſe of theſe Spheres, I think it convenient to premiſe theſe following Cautions.

1. That the Student ought to be already learnt in the Rudiments of Aſtronomy and Geography, and the meaning of all uſual Terms of Art; if he be not, I ſhall refer him to the Uſe of

of the Globes, Book I. *And withal, wiſh he were acquainted with the Uſe of the Vulgar Globes; becauſe he that underſtands their Uſes perfectly, may much more eaſily underſtand the Uſes of the* Copernican Spheres; *for in many Problemes, the Phraſes being varied, the Precept is the ſame in both. As for inſtance; in the* Uſe of the Globes *you are directed to move the* Meridian *through the* Horizon *: but by changing the Words of the Precept, you muſt in the* Uſe of the Sphere, *move the* Horizon *through the* Meridian.

Again, you are in the Uſe of the Globes *directed to bring the place of the Sun to the* Horizon, *or* Meridian, *&c. and if you apply that Precept, to the* Uſe of the Spheres, *you muſt read, Bring the* Horizon *or* Meridian *to the Sun (or which is all one, to the Suns place) becauſe in the Globes, the* Horizon *is fixt, and the Suns place movable : but in the Spheres, the Suns Place is fixt, and the* Horizon *movable.*

3. *Note that in many places where I ſay,* Bring ſuch a Circle, or ſuch a Degree, to the Sun, *it is all one as if I had ſaid,* Bring it to the Degree the Sun is in in the Ecliptick; *for the Sun lying in the Plain of the Ecliptick, the De-*

gree

gree of the Ecliptick the Sun is in, lies juſt in a ſtraight Line between the Sun and the Center of the Earth; and your Probleme *is therefore more practicable, and the anſwer required, commonly more diſtinctly found, becauſe of the Suns diſtance from the Center of the Earth.*

4. *Note that when I ſay,* Bring the Meridian to the Sun, *or ſome other place; I mean that Line on the* Meridian *which is deſcribed on the middle of the outermoſt ſide between the two edges; for that Line divides the Axis of the Earth exactly into two equal parts: And I alſo mean that Semi-Circle of the Meridian, which hangs over the firſt* Meridian *on the Terreſtrial Ball, Becauſe that Semi-Circle alwayes faces the Sun at Noon; and on it,* viz. *in the Poles of the* Horizon *is the* Zenith *alwayes repreſented in the meeting of the two Vertical Circles.*

And when I ſay, Bring the Horizon, *I mean the outermoſt edge on the upper Plain of the Horizon. And when I name any other Circles or Lines about the Sphere, I mean that Line in thoſe Circles that is graduated; which Line ſometimes lies in the middle of the Circle, as in the Equator and Colures it doth; and ſometimes on the edge; as in the Vertical ſemi-Circles, and ſemi-Circles of Latitude, becauſe that Edge runs into*

the

the middle of the Axis of theſe ſemi-Circles.

2. *Note that becauſe there is two Circles belonging to the particular Sphere, whereon the Signs of the Ecliptick is depicted,* viz. *that great one ſupported by the Banneſters, and that ſmal one which encompaſſes the Sphere, wherein the Earth is hung; Therefore, for diſtinction ſake, I ſhall call the firſt of them,* viz. *the great one,* The Zodiack; *and the ſmall one which encompaſſes the Sphere of the Earth,* The Ecliptick.

Note that in ſeveral Problemes, *where I ſay,* Make a Mark in ſuch a Line or Circle at ſuch a Degree, *to repreſent any Star, Planet or other Point in Heaven; If that Mark be made with Black-Lead, you may with a little Bread rub it out again when you pleaſe, and the Sphere will be never the worſe for it.*

Prob. I.

How the twofold Motion of the Earth is repreſented on the Sphere: And how many Miles the Earth moves in any given-time, by vertue of each Motion.

THe Earth hath a twofold Motion; *viz.* a Diurnal, and an Annual Motion; The Diurnal Motion is ſhewn by turning the Earth about upon its own Axis from Weſt to Eaſt: This Motion is performed in 24 hours; as you may ſee by the Index of the Hour-Circle; for in one Revolution it paſſes through all the 24 hours on it: and in this Converſion, one part or other of the Earth alwayes ſtands againſt the Sun, and the oppoſite part is alwayes hid from the Sun. In that part which ſtands directly againſt the *Sun*, it is full Noon; and in that part which is moſt remote from the Sun, it is Midnight; and in all the other parts of the Earth, *viz.* where the Sun is obliquely beheld in the Eaſt, it is Morning; and in thoſe parts where the Sun is obliquely beheld in the Weſt, it is Evening; but in thoſe parts of the Earth that do not at all behold the *Sun*, it is Night.

Now what meaſure of ſpace your Habitation moves in any given-Time, by vertue of this Converſion, you ſhall thus learn to know one degree of Longit. in the Equinoctial contains 60 *Engliſh* Miles; as was ſhewn in the *Uſe of the Globes*, *Book* 3. *Prob.* 10. And the Earth by its Diurnal Converſion, moves 15. deg. in 1 hours time; that is, 900 Miles; and ſo proportionably for any other meaſure of Time: But though a Degree of the

the Equinoctial contain ſo many Miles, yet doth not a Degree of Longitude in any other Parallel contain ſo many: for that all Parallels to the Equinoctial grow leſs and leſs in a proportion, till they come to the Pole.

Now that you may know how many Miles every Degree of Longitude contains in any Latitude, I have inſerted this following Table, where in the firſt

1	59.59	11	58.54	21	56. 1	31	51.26	41	45.16
2	59.58	12	58.41	22	55.38	32	50.53	42	44.35
3	59.53	13	58.28	23	55.14	33	50.19	43	43.53
4	59.51	14	58.13	24	54.49	34	49.45	44	43.10
5	59.46	15	57.57	25	54.23	35	49. 9	45	42.26
6	59.40	16	57.41	26	53.56	36	48.32	46	41.41
7	59.33	17	57.23	27	53.28	37	47.55	47	40.55
8	59.25	18	57. 4	28	52.59	38	47.17	48	40. 9
9	59.16	19	56.44	29	52.29	39	46.38	49	39.22
10	59. 5	20	56.23	30	51.58	40	45.58	50	38.43
51	37.46	61	29. 5	71	19.32	81	9.23		
52	36.56	62	28.10	72	18.32	82	8.21		
53	36. 7	63	27.40	73	17.33	83	7.19		
54	35.16	64	26.18	74	16.32	84	6.16		
55	34.25	65	25.21	75	15.32	85	5.14		
56	33.33	66	24.24	76	14.31	86	4.11		
57	32.41	67	23.27	77	13.30	87	3. 8		
58	31.48	68	22.29	78	12.28	88	2. 5		
59	30.54	69	21.30	79	11.27	89	1. 3		
60	30. 0	70	20.31	80	10.25	90	0. 0		

Column you have the Degree of Latitude, and in the next Column the number of whole Miles and Minutes, or the ſixtieth part of a Mile that it contains; ſo that by ſeeking the Latitude of your Place in the firſt Column, the ſecond Column gives you the number of Miles, and Minutes of Miles contained in one

degree of Longitude in that Latitude; And by multiplying those Miles by 15, you have the number of Miles, your Habitation moves in one hours time.

Example.

I would know how many Miles *London* moves Eastwards in one hours time; the Latitude of *London* is $51\frac{1}{2}$ degrees; therefore I examine in this Table how many Miles are contained in the degree of Longitude in the Latitude of $51\frac{1}{2}$ degrees: But because this Table is made only for whole degrees, therefore I substract the number of Miles and Minutes contained in a degree of Longitude, in the Latitude of 52 degrees from those contained in the Latitude of 51 degrees; and half that difference I substract from the Miles and Minutes answering to 51 degrees; so shall the the Remainder shew (in this case near enough) the Miles and Minutes answerable to $51\frac{1}{2}$ deg. which by this Example is 37 Miles 21 Minutes, or sixtieth parts of a Mile; and this multiplyed by 15, the number of degrees, the Earth turns Eastwards, in one hours time gives 560 Miles 15 Minutes, which is one quarter of a Mile more; so that *London* moves Eastwards $560\frac{1}{4}$ Miles in one hours time; and so proportionably for any other Measure of Time.

The Annual Motion is shewn by turning about the Rundle, according to the succession of Signs, till its Index passes through all the Dayes in the Circle of Months. In this Revolution you may see the Earth pass through all the Signs of the Zodiack. And you may also see, that when the Earth is in any Sign, the Sun is seen from the Earth to be in the opposite Sign; as if the Earth enter *Aries*, the Sun shall in appearance from

from the Earth, enter *Libra*: if the Earth enter *Cancer*, the Sun ſhall ſhew as if it entered *Capricorn*, &c.

By this Revolution, the Dayes and Nights are lengthned or ſhortned in all places of the Earth, and that according to their ſcituation on the North or South ſide the Equator; and the Seaſons of the Year are varied into Spring, Summer, Autumn, Winter.

When the Earth is in Southern Signs, the Northern Parts of the Earth have their longeſt dayes; and when it is in Northern Signs, the Southern Parts of the Earth have their longeſt dayes; the reaſon is, becauſe the Earth moves not upon the Poles of the Ecliptick, but upon two Poles $23\frac{1}{2}$ degrees declining from the Poles of the Ecliptick, by which means a greater portion of the Northern half of the Earth faces the Sun, when the Earth is in Southern Signs, than doth when the Earth is in Northern Signs; and therefore makes the Diurnal exceed the Nocturnal Arch, and the Raies (and conſequently the heat) of the Sun is more perpendicularly darted on the Northern parts of the Earth Then, than when the Sun is in Southern Signs, becauſe the Northern Pole inclines then towards the Sun; and when the Sun is in contrary Signs, it recedes from the Sun; as may be ſeen by the Sphere.

Now to know what meaſure of ſpace the Earth moves through the Heavens in any given-time, by vertue of its Annual Motion: you muſt conſider the diſtance of the Earth from the Sun, which according to the general received opinion, is 604 Diameters of the Earth; which multiplyed by 6872 (the number of Miles contained in the Earths Diameter) makes 4150688 for the diſtance in Miles the Earth hath from the Sun, which is half the Diameter of the Earths Orb; this doubled, makes the whole Diameter of the Earths Orb contain 11301376 Miles. The

The Diameter of every Circle bears ſuch proportion to the Circumference, as 7 does to 22; therefore the Circumference of the Earths Orb, contains 35518610 Miles; ſo that in one whole year the Earth running through its Orb, runs 35518610 Miles, which divided by 365, the number of dayes in one year, gives 97311 Miles the Earth runs in one day, which 97311 divided by 24, the number of hours in one day, gives 4054 Miles the Earth runs in one hour: which 4054 divided by 60, the number of Minutes in one hour, gives $67\frac{1}{2}$ Miles the Earth runs in one Minute.

Theſe two motions (*viz.* the Diurnal and Annual) may aptly be compared to the twofold motion an Iron Bullet has in a Bowl, when Sea-men make Muſtard; for as that Bullet runs round the Circumference of the whole Bowl, and alſo turns round upon its own ſuperficies (as upon its Axis) So the Earth in its Annual Motion, runs round through the whole Zodiack; and in its Diurnal Motion turns its Superficies round upon its own Axis.

Prob. II.

Of the Inclination of the Axis of the Earth.

NOtwithſtanding this twofold motion aforeſaid, yet doth the Axis (and therefore the two Poles) of the Earth reſpect the ſame parts of Heaven, and alwayes remains parallel to it ſelf, though the Earth run through all the Signs of the Zodiack. The reaſon of this Inclination is attributed to ſome Magnetick Vertue in the Poles of the Earth, which makes them reſpect

ſpect alwayes the ſame part of Heaven; as ſhall be ſhewed hereafter when I ſpeak of the Preceſſion of the Equinoctial: I do not ſay the ſame *Point* in Heaven, but the ſame *Part* of Heaven; that is, the Axis doth alwayes reſpect thoſe Stars about the North and South Poles, and hath that ſmall motion formerly attributed to the Starry Heaven.

Now though I told you in the laſt *Probleme*, that by the Annual Motion of the Earth, the Dayes and Nights were lengthned and ſhortned, and the Seaſons of the Year altered, yet if the Axis of the Earth did not thus decline, thoſe ſeveral Mutations could not happen; for if the Axis of the Earth ſtood parallel to the Axis of the Ecliptick, the Sun would alwayes be in the Equinoctial, and by conſequence, the Dayes and Nights alwayes of equal length: And the temper of the Year in every place of the Earth alwayes in the ſame condition.

PROB. III.

Of the ſeveral Conſtitutions of the Sphere.

THe Conſtitution of the Sphere is varied according to the ſeveral Poſitions of the Pole with the Horizon, as was taught before in the *uſe of the Globes*. Now that you may ſet the Sphere to thoſe Poſitions, do thus; Move the Horizon through the Meridian, till the Axis of the Earth lie in the Horizon; ſo have you a direct Sphere. *Book. I. cap. 3. Sect. XVI.*

To repreſent a parallel *Sphere*, Move the Horizon through the Meridian, till the Equinoctial on the Earth lie in the Horizon.

And

And to repreſent an oblique Sphere, Move the Horizon to any number of degrees on the Meridian between the Equinoctial and the Pole. Theſe need no Examples.

Prob. IV.

The Day of the Month given to find the Place of the Sun, and the Place of the Earth in the Ecliptick.

SEek the Day of the Month in the Circle of the Months in the bottom of the frame, and bring the Index of the movable Rundle to that day, ſo ſhall the ſame Index alſo cut in the Circle of Signs the Degree of the Ecliptick the Sun appears to us to be in; and ſo ſhall the Earth be placed in the oppoſite degree of the Zodiack, which is the degree the Earth is in that day.

Example.

The Day given is *May* 10. Therefore I ſeek in the great hollow Circle in the bottom of the Frame for *May* 10, and bring the Index of the movable Rundle to that Day, and find that whiles it lies upon that Day in the Circle of Months, it cuts in the Circle of Signs, *Taurus* 29, which ſhews that the Sun is that day at Noon in 29 degrees of *Taurus*.

Then looking in the Zodiack, I find the Earth ſtand juſt againſt *Scorpio* 29, which ſhews that the Earth that Day at Noon is in 29 Degrees of *Scorpio*.

Prob.

PROB. V.

The Day of the Month given, To rectifie the Sphere fit for uſe in any Latitude: And to ſet it correſpondent to the ſcituation of Heaven.

BRing the Index of the movable Rundle to the Day of the Month, and elevate the Horizon to the Latitude of your place; then bring the Meridian to the Sun, and the Index of the Hour-Circle to XII on the Hour-Circle. Laſtly, Bring the Center of the Earth, the Sun in the Sphere, and the Sun in Heaven, into a ſtraight line, ſo ſhall the Earth be rectified to its place in Heaven, the Horizion to its Latitude on Earth, the Circles on the Sphere agreeable to thoſe in Heaven, and the whole correſpondent with the Heavens for that Day at Noon.

Example.

May 10 at Noon I would rectifie the *Sphere*, to correſpond with the appearance of Heaven here at *London*, where the Pole is elevated 51½ deg. above the Horizon in North Latitude; Therefore I ſeek *May* 10 in the Circle of Months on the bottom of the Frame, as by *Prob.* 4. ſo is the Earth placed in the Sphere in that Sign and degree of the Ecliptick it is placed in in Heaven, which in this Example is in *Taurus* 29. Then I elevate the Horizon to the Latitude of *London*; that is, I ſlide the Horizon through the Brazen Meridian, till the Northern ſide of the upper plain of it cut on the Meridian 51½ degrees counted

from the Pole towards the Equinoctial. So is the Horizon rectified for this Latitude. Then I turn about the Meridian till it come to the Sun, or, which is all one, to the Place of the Sun in the Ecliptick (as I told you in the *Preface*, in *Note* 2.) I turn the Index of the Hour-Circle to the uppermoſt XII in the Hour-Circle, for that is the 12 at Noon; the other XII, the 12 at Mid-night. So is the Hour-Circle rectified. And laſtly, I turn the *Sphere*, ſo as that when the Axis of this Artificial Earth lies parallel with the Axis of the Natural Earth, the Sun in the Sphere, the Center of the Earth, and the Sun in Heaven, may all at once lie in a ſtraight line, ſo ſhall the Sun in the *Sphere* be ſcituate as in reſpect of the Earth, as it is in Heaven; the Circles of the Sphere correſpond with the ſame Circles in Heaven; the Horizon of this Artificial Earth lie Parallel to the Horizon of *London* on the natural Earth; and thoſe Stars you ſhall ſet to their proper place (as you ſhall be taught by *Prob.* 25.) ſhall have the ſame ſcituation, Azimuth, Elevation, *&c.* on this material Sphere, that at the ſame time they ſhall have in Heaven, *viz.* as on *May* 10 at 12 a clock at Noon here at *London*.

And if you would ſet the *Sphere* to correſpond with any other Time of the Day or Night than Noon (after the aforeſaid Operations) turn but the Earth till the Index of the Hour-Circle come to your intended Hour, ſo ſhall the Sphere be rectified to that Hour alſo.

PROB.

PROB. VI.

The Day of the Month given, To find the Declination of the Sun.

REctifie the Earths Place, as by *Prob.* 5. ſo have you by the ſame *Probleme* the Suns Place in the Zodiack; then bring the Meridian to the Sun; and the number of Degrees comprehended between the Equinoctial and the body of the Sun, is the Suns Declination for that Day at Noon.

Example.

I would know the Declination of the Sun for *May* 10; Therefore I bring the Index of the movable Rundle to *May* 10 in the Circle of Months, and find it then cut in the Circle of Signs, *Taurus* 29, as before, which is the degree the Sun is in; then turning the Meridian directly towards the Sun, I find 20 degrees, 5 minutes on the Meridian, comprehended between the Equinoctial and the Body of the Sun, which is the Suns Declination for that Day at Noon.

PROB. VII.

The Day of the Month given, To find the Right Aſcention of the Sun at Noon, and alſo the Oblique Aſcention or Deſcenſion of the Sun.

REctifie the Earths place to the Day of the Month, as by *Prob.* 5. and bring the Meridian to the Sun; And the number of Degrees on the Equinoctial contained between the Vernal Colure, and the Body of the Sun is the Degrees of the Right Aſcention.

Example.

May 10 at Noon I would know the Right Aſcention of the Sun; Therefore I bring the Index of the Rundle to the Day of the Month, and turn the Meridian juſt towards the Sun, and then find it cut the Equinoctial in 56 deg. 46 min. reckoned from the Vernal Colure: Therefore I ſay, The Right Aſcention of the Sun, *May* 10 at Noon, is 56 deg. 46 min.

For the Oblique Aſcention of the Sun, Turn the Earth till the Eaſt-ſide the Horizon ſtands againſt the Sun, And the Degree of the Equinoctial then at the Horizon, is the Degree of the Oblique Aſcention.

For the Oblique Deſcention, Turn the Earth till the Weſt-ſide of the Horizon comes to the Sun; And the Degree of the Equinoctial then at the Horizon is the Degree of the Oblique Deſcention of the Sun. Theſe need no Examples.

PROB. VIII.

The Day of the Month, and Latitude of the Place given, To find the Meridian Altitude.

BRing the Index of the Rundle to the Day of the Month, and rectifie the Horizon to the Latitude of your Place, as by *Prob.* 5. then bring the Meridian to the Sun; And the number of Degrees on the Meridian comprehended between the Horizon and the Sun, is the Meridian Altitude.

Example.

May 10 here at *London*, I would know the Meridian Altitude; Therefore I bring the Index of the Rundle to *May* 10 in the Circle of Months, and the Horizon to 51½ deg. on the Meridian: Then I turn the Meridian juſt towards the Sun, and find 58½ deg. of the Meridian, comprehended between the plain of the Horizon, and the body of the Sun; Therefore I ſay, the Meridian Altitude is 58½ deg. on *May* 10 here at *London*.

PROB. IX.

The Latitude of the Place, Day of the Month, and Hour of the Day given, To find the Altitude of the Sun.

BRing the Index of the Rundle to the Day of the Month, and rectifie the Horizon and Hour-Index, as by *Prob*, 5. then turn the Earth till the Hour-Index come to the Hour of the Day, and bring the Vertical Circle to the Sun; And the number of Degrees of the Vertical Circle that tranſites the Sun, is the number of Degrees the Sun is elevated above the Horizon.

Example.

May 10 at 53 min. paſt eight a clock in the morning, I would know the heighth of the Sun above the Horizon; Therefore I bring the Index of the Rundle to *May* 10 in the Circle of Months, and rectifie the Horizon and Hour-Index, as was taught *Prob.* 5. Then I turn the Earth till the Index of the Hour-Circle points to 53 min. paſt 8 a clock in the Hour-Circle: Then I bring the Eaſtern Vertical Circle to the Sun, and find that then 40 deg. of the Vertical Circle ſtands againſt the Sun, Which ſhews that the Sun is elevated 40 deg. above the Horizon, or (which is all one) the Horizon is in that Azimuth depreſſed 40 deg. below the Sun.

PROB. X.

The Day of the Month, the Latitude of the Place, and the Altitude of the Sun given, To find the Hour of the Day.

BRing the Index of the movable Rundle to the day of the Month in the Circle of Months, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then turn the Earth till you can fit the Horizon to the given-Altitude upon the Vertical Circle, right againſt the Sun; So ſhall the Hour-Index point at the hour of the day on the Hour-Circle: Yet herein reſpect muſt be had to the Fore or Afternoon, which by a Quadrant you muſt obſerve; as by *Prob.* 13. *Book* 2. of the *Uſe of the Globes*; for the Sun comes twice a day to the ſame heighth, unleſs it be in its Meridian Altitude.

Example.

May 10 the Sun is elevated here at *London* 40 deg. above the Horizon; Therefore, having brought the Index of the movable Rundle to the Day of the Month in the Circle of Months, and rectified the Horizon and Hour-Index, as by *Prob.* 5. I turn the Earth and Vertical Circle till I can fit them at 40 deg. on the Vertical Circle againſt the Sun; So ſhall the Index of the Hour-Circle point at 8 a clock, 53 min. which ſhews that *May* 10 here at *London*, when the Sun has 40 deg. of Altitude, it is 8 a Clock, 53 min. in the morning.

PROB.

PROB. XI.

The Day of the Month, and Latitude of the Place given, To find the Amplitude of the Sun; and at what Point of the Compaſs it riſes.

BRing the Index of the movable Rundle to the Day of the Month in the Circle of Months, and rectifie the Horizon, as by *Prob.* 5. Then bring the eaſt-ſide the Horizon to the Sun; And the number of Degrees of the Horizon that ſtands againſt the Sun, is the Amplitude of the Sun, and bears its denomination either of North or South, according to its Inclination to either Point in the Horizon.

If you would know upon what Point of the Compaſs the Sun riſes, Look in the Circle of Winds, which of them the Sun ſtands againſt; And the Name you find there, is the Name of the Point of the Compaſs the Sun riſes at.

Example.

May 10 I would know the Amplitude of the Sun here at *London*; Therefore I bring the Index of the movable Rundle to the Day of the Month in the Circle of Months, and rectifie the Horizon as by *Prob.* 5. Then I turn the Horizon till ſome part of the Eaſtern edge of it ſtands directly againſt the Sun, and examine what Degree of the Horizon it is that ſo ſtands againſt the Sun; which in this *Example* I find to be 122 deg. 40 min. reckoned from the South Point of the Horizon. But I muſt know how many Degrees are contained

tained between the East Point and the Point in the Horizon against the Sun; Therefore I ſubſtract 90 from 122 deg. 40 m. and the remains is 33 deg. 20 min. And becauſe it is to the Northwards of the East Point, Therefore I ſay, *May* 10 here at *London*, the Sun hath 33 deg. 20 min. North Amplitude.

If the Sun had had South Amplitude, I ſhould have ſubſtracted the Degree of the Horizon, that had ſtood againſt the Sun from 90, and the Remnant had been the South Amplitude of the Sun.

To know at what Point of the Compaſs the Sun Riſes, I keep the Earth in its poſition, and look in the Circle of Winds on the Horizon, and find that North-East and by East ſtands right againſt the Sun. Therefore I ſay, *May* 10 here at *London*, the Sun riſeth upon the North-East and by East Point of the Compaſs.

PROB. XII.

The Day of the Month given, To find the Diurnal and Nocturnal Arch in any given-Latitude.

BRing the Index of the movable Rundle to the Day of the month in the Circle of Months, and rectifie the Horizon, as by *Prob.* 5. Then turn the Earth about till ſome part of the Horizon ſtand right againſt the Sun; And the Degree of the Equinoctial that comes to the Sun with the Horizon is half the Diurnal Arch of the Sun, which doubled, and that ſum ſubſtracted from 360, leaves the Nocturnal Arch of the Sun.

Example.

May 10 here at *London*, I would know the Diurnal Arch of the Sun; Therefore I bring the Index of the movable Rundle to *May* 10 in the Circle of Months, and rectifie the Horizon to the Latitude of *London*, as by *Prob.* 5. Then I turn about the Earth till the Horizon come to the Sun, and find 117 deg. of the Equinoctial then at the Sun, which is the Semi-diurnal Arch; which doubled, makes 234 for the Diurnal Arch; And which 234 ſubſtracted from 360, leaves 126 deg. for the Nocturnal Arch of the Sun.

PROB. XIII.

The Day of the Month, and Latitude of the Place, given, To find what Hour the Sun comes to the Eaſt or Weſt Point of the Horizon; and what Almicantar it then ſhall have.

BRing the Index of the movable Rundle to the Day of the month in the Circle of months, And rectifie the Horizon and Hour-Index, as by *Prob.* 5. And bring the Vertical Circle to the Eaſt Point of the Horizon, if it be the Suns Eaſting you would enquire, or to the Weſt Point of the Horizon, if you would enquire its Weſting: Then turn the Earth till the Vertical Circle come to the Sun, So ſhall the Hour-Index point to the Hour of the Day on the Hour-Circle; And the Degree of the Vertical Circle at the Sun, ſhall be the Almicantar of the Sun.

Exam-

Example.

May 10 here at *London*, I would know what Hour the Sun comes to the East and West Points of the Horizon, and what Almicantar it then shall have: Therefore I bring the Index of the movable Rundle to the Day of the month in the Circle of months, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring one of the Vertical Semi-Circles to the East Point of the Horizon, and the other to the West Point of the Horizon: And I turn the Earth till the Eastern Vertical Circle come to the Sun; Then I look on the Hour-Index, and find it point to 7 min. past VII a clock in the morning; which is the time that the Sun comes to the East; And examining the Vertical Circle, I find 25 deg. 30 min. at the Sun; Which is the Almicantar of the Sun at that time: As you may learn by *Prob.* 15.

To know the Hour it comes to the West, Turn the Earth till the Vertical Circle placed in the West, come to the Sun; So shall the Index of the Hour-Circle point at 53 min. past IIII a clock Afternoon, for the Time that the Sun comes to the West Point of the Horizon.

And examining again the Vertical Circle, I find 25 deg. 30 min. of it against the Sun, for the Almicantar, as before.

Prob. XIV.

The Day of the Month, the Latitude of the Place and Hour of the Day, given, To find the Azimuth of the Sun.

BRing the Index of the movable Rundle to the Day of the Month, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then turn the Earth till the Hour-Index point to the Hour of the Day; And bring the Vertical Circle to the Sun; So shall the number of Degrees of the Horizon that the Vertical Circle cuts, counted from the East Point, either Northwards or Southwards, according to the scituation of the Degree, be the Degrees of Azimuth that the Sun hath, if before Noon. Or the Number of Degrees of the Horizon that the Vertical Circle cuts, counted from the West Point of the Horizon, either Northwards or Southwards, according to the scituation of the Degree, be the Degrees of Azimuth that the Sun hath, if after Noon.

Example.

May 10 at 53 min. past 8 a clock in the Morning here at *London*, I would know the Azimuth of the Sun; Therefore I bring the Index of the movable Rundle to the Day of the Month, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I turn the Earth back till the Index of the Hour-Circle point to 53 m. past VIII a clock in the Hour-Circle: Afterwards I bring the Eastern Vertical Circle to the Sun; and find

find that then the Vertical Circle cuts the Horizon in 61 deg. 35 min. from the South Eaſtwards: Therefore I ſubſtract 61 deg. 35. min from 90, and there remains 18 deg. 25 min. for the Azimuth of the Sun: And becauſe 18 deg. 25 min. are numbred from the Eaſt Point of the Horizon Southwards; Therefore I ſay, The Azimuth is from the Eaſt Southwards, 18 deg. 25 min.

PROB. XV.

The Day of the Month, Latitude of the Place, and Hour of the Day, given, To find the Almicantar of the Sun.

THis *Probleme* is in effect the ſame with *Prob.* 9. and the Operation is the ſame; for if the Altitude be 40 deg. as it is in the Example in that *Probleme*; By that Operation the Almicantar will be 40 deg. *&c.* See *uſe of the Globes, Book* 2. *Prob.* 23.

PROB. XVI.

The Day of the Month, and Latitude of the Place, given, To find the Hour of Suns Riſing or Setting; And the length of Day or Night.

BRing the Index of the movable Rundle to the Day of the month in the Circle of months; and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then turn the Earth Eaſtwards, till ſome part of the Eaſt ſide of the Horizon ſtands directly againſt the Sun; So ſhall the Index of the Hour-Circle point to the

Hour of the Sun-Riſing. Then turn the Earth again till ſome part of the Weſt ſide the Horizon, ſtands directly again the Sun: So ſhall the Index of the Hour-Circle point to the Hour of Sun-Set.

To know the length of the Day, Double the Hours and Minutes of Sun-Set, and that ſhall be the length of the Day.

Then ſubſtract the length of the Day from 24 Hours, and the Remainder is the length of the Night.

Example.

May 10 I would know the time of Sun Riſing and Setting, and the length of Day and Night here at *London*; Therefore I bring the Index of the movable Rundle to the Day of the month in the Circle of months, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I turn the Earth Eaſtward, till ſome part of the Eaſtern ſide the Horizon ſtands directly againſt the Sun; and looking at the Hour-Index, I find it point at IIII a clock, 10 min. which ſhews that the Sun Riſes at 10 min. paſt IIII a clock in the Morning.

Then turning the Earth ſtill Eaſtwards, till ſome part of the Weſtern ſide the Horizon, ſtands directly againſt the Sun, I find the Index point at 50 min. paſt VII; which ſhews that the Sun ſets at 50 min. paſt VII clock at Night.

Then by doubling 7 hours 50 min. the time from Noon, I have 15 hours, 40 min. for the length of the whole Day: And ſubſtracting 15 hours, 40 min. from 24 hours, I have 8 hours, 20 min. for the length of the Night.

PROB.

Prob. XVII.

The Day of the Month, and Latitude of your Place, given, To find the begining, duration and ending of Twilight, Morning and Evening.

BRing the Index of the movable Rundle to the day of the month in the Circle of months, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then turn the Earth Eaſtwards, till the Horizon be elevated 18 deg. on the Vertical Circle above the Sun; ſo ſhall the Sun ſhew it ſelf to the Eaſtwards of your Horizon, as it is in Heaven; and the Index of the Hour-Circle ſhall ſhew the Hour and Minute that Twilight begins in the Morning.

If you will know when it ends at Night, Turn the Earth till the Sun appears Weſtwards from the Earth, and till the Horizon be elevated 18 deg. on the Vertical Circle above the Sun; ſo ſhall the Index of the Hour-Circle ſhew in the Hour-Circle the hour and minute that Twilight ends in the Evening.

Example.

May 10 here at *London*, I would know when Twilight begins in the Morning, and ends at Night; Therefore I bring the Index of the movable Rundle to *May* 10 in the Circle of Months; and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring the Vertical Circle to the Sun, and keep it there; And turn the Earth Weſtwards, till the Horizon riſe 18 deg. above the Sun on the Vertical Circle; ſo ſhall the

Sun

Sun appear to us in the ſame ſcituation it hath in Heaven, *viz.* in an Eaſtern ſcituation; and the Index of the Hour-Circle will point to 8 min. paſt I a clock in the morning, which is the Time that Twilight begins.

To know when Twilight ends, I turn the Earth ſtill Weſtwards, according to its Progreſs, and bring the Weſtern Vertical Semi-Circle to the Sun, and again turn the Earth till the Horizon is elevated on it 18 deg. above the Sun, as before; ſo ſhall the Index of the Hour-Circle point at 52 min. paſt X a clock at Night, which ſhews that Twilight then ends.

If you ſubſtract 1 hour, 8 min. the begining of Twilight, from 4 hours 10 min. the Time of Sun-Riſing that Day (as you may find by *Prob.* 16.) it leaves 3 hours, 2 min. for the duration of Twilight.

Prob. XVIII.

The Day of the Month given, To find what Alteration of Declination the Sun muſt have to make the Day an Hour longer or ſhorter; And in what number of dayes it will be.

BRing the Index of the movable Rundle to the day of the Month in the Circle of Months; And bring the Eaſt ſide the Horizon to the Sun, and mark the Degrees of the Horizon. Then alter the ſcituation of the Horizon, till its Poles become the Poles of the World, and the Plain of the Ecliptick the Horizon to the Poles, and what before were the Vertical Circles, now Meridians. Then bring your new Poles to the Summer Solſtice, if your Latitude be North, or to the Winter Solſtice, if your Latitude be South: Then ſet the

the ſame number of Degrees on the Ecliptick, counted from the firſt Point of *Aries*, that you at firſt markt on the Horizon; and bring one of the Vertical Circles to that number of degrees, and with a Black-Lead make a mark at that Degree on the Vertical Circle. Then move the Vertical Circle $7\frac{1}{2}$ deg. forwards on the Equinoctial if the dayes increaſe, or backwards if they decreaſe; and mark again what Degree of the Vertical Circle then cuts the Ecliptick; And the number of Degrees, contained between the firſt and ſecond mark on the Vertical Circle, is the number of Degrees that the Declination increaſes or decreaſes to make the Dayes an Hour longer or ſhorter.

Example.

The Suns Place is *Taurus* 10; I would know how much it muſt alter its Declination, before the Day is an Hour longer here at *London*. Therefore I bring the Index of the movable Rundle to the Day of the Month in the Circle of Months, and rectifie the Horizon to the Latitude of *London*, as by *Prob.* 5. Then I bring the Eaſt ſide the Horizon to the Sun, and with a Black-Lead Penſil, make a mark at the Degree of the Horizon the Sun ſtands againſt. Then I alter the Scituation of the Horizon, by moving it through the Meridian, till its Poles, *viz.* the Zenith and Nadir, become the Poles of the World: for then ſhall the Plain of the Ecliptick become the Horizon to thoſe Poles, and the former Vertical Circles now Meridians. Then I turn theſe new Poles to the Summer Solſtice (becauſe the Latitude of *London* is North) and keep it there till the Operation be finiſh'd. Afterwards I count the ſame number of Degrees on that Ecliptick (now Horizon)

numbred from the firſt Point of *Aries*, that I made a mark at in the Horizon when it ſtood in its former poſition, and to this number of Degrees I bring one of the Vertical Circles (now Meridians) and on it with a Black-Lead Penſil, as before, make a mark cloſe by the edge of the Ecliptick. Then keeping the Sphere ſtill in this poſition, I move the Vertical Circle forward according to the ſucceſſion of Signs, till it paſſes through $7\frac{1}{2}$ deg. of the Equator; And where the Ecliptick again cuts the Vertical Circle, I make another mark; Then I count the number of Degrees contained between theſe two marks on the Vertical Circle, and find them a little more than five; Therefore I ſay when the Sun is in 10 deg. of *Taurus*, it muſt alter its Declination a little more than 5 deg. to make the Day an Hour longer here at *London*.

Now to know in what number of dayes it ſhall alter this Declination, you muſt find what Degree of the Ecliptick the Sun will be in at its ſecond Declination.

Now to know in what number of dayes the Sun ſhall alter this Declination from its firſt, You muſt find what Degree of the Ecliptick the Sun will be in at his Second Declination; which you may do by the converſe of *Prob.* 6. And if you move the Index of the Rundle from the Suns firſt place in the Circle of Signs to the Suns ſecond Place, it will paſs over in the Circle of Months, the number of Dayes, that muſt paſs away before they alter an Hour in their length.

PROB. XIX.

To know how much the Pole is Raiſed or Depreſſed, where the longeſt Day is an Hour longer or ſhorter than it is in your Habitation.

REctifie the Horizon to the Latitude of your Place, and obſerve what Degree of the Equator the Meridian cuts: Keep the Earth in that poſition, and make a prick on the Tropick where the Meridian cuts it. Then move the Earth Weſtwards, if you would know where the Dayes are an Hour longer; or Eaſtwards, if you would know where they are an Hour ſhorter, till the Meridian paſs through $7\frac{1}{2}$ deg. of the Equinoctial; and where the Meridian cuts the Tropick, make another prick; Then turn the Earth till the Horizon come to the firſt prick on the Tropick; and keeping the Earth in that poſition, move the Horizon through the Meridian till the Horizon touch the ſecond prick: So ſhall the Arch of the Meridian, contained between the Horizon and the Pole, be the number of Degrees that the Pole is elevated in thoſe places where the Day is an Hour longer than in your own Habitation.

Example.

I would know in what Latitude the longeſt Day is an Hour longer than it is at *London*: Therefore I rectifie the Horizon to $51\frac{1}{2}$ deg. and obſerve the Degree of the Equator that is at the Meridian; Then keeping the Sphere in this poſition, I make a prick on the Tro-

pick of *Cancer*, where the Meridian cuts it. Then I move the Earth Weſtwards (becauſe I examine where the Dayes are an Hour longer) till the Meridian paſs through $7\frac{1}{3}$ deg. from the firſt place it was at in the Equator. And where the Meridian cuts the Tropick again, I make another prick; Then I turn the Earth till the Horizon come to the firſt prick on the Tropick, and keep the Earth in this poſition: Afterwards I Depreſs the Horizon through the Meridian till it come to the ſecond prick on the Tropick of *Cancer*; Then examining what Degrees are contained between the Pole and the Horizon, I find $56\frac{1}{3}$: Therefore I ſay where the Pole is elevated $56\frac{1}{3}$ deg. above the Horizon, the Dayes are an Hour longer than here at *London*.

If you would know how much the Pole is raiſed more than at *London*, Subſtract the greater number of Degrees of Latitude from the leſſer number of Degrees of Latitude, and the remainder is the number of Degrees; which in this *Example* is 5 degrees.

Prob. XX.

To find in what Place of the Earth the Sun is in the Zenith the Day and Hour given: And alſo in what ſeveral Places of the Earth the Sun ſhall ſtand in the Horizon at the ſame time.

BRing the Index of the movable Rundle to the Day of the Month, and rectifie the Hour-Index, as by *Prob.* 5. Then ſeek the Suns Declination, as by *Prob.* 6. And turn the Earth Eaſtwards till the Index point

point to the given-Hour; So ſhall the number of Degrees of the Equinoctial that the Meridian paſſes through while the Earth is ſo turning, be the number of Degrees of Longitude Eaſtwards from your Habitation the Place ſhall have in the Parallel of the Suns Declination.

Example.

May 10 When it is 53 min. paſt 8 a clock here at *London*, I would know in what place of the Earth the Sun is in the Zenith; Therefore I bring the Index of the movable Rundle to *May* 10, and rectifie the Hour-Index by bringing the Meridian to the Sun; and then, as by *Prob.* 6. I may find the Declination to be 20 deg. 5 min. Then keeping the Earth in this poſition, I obſerve what Degree of the Equinoctial the Meridian is at, and find it to be 56 deg. 46 min. Afterwards I turn the Earth Eaſtwards till the Index of the Hour-Circle point to 53 min. paſt VIII a clock. And examine again what degree of the Equinoctial the Meridian is at, and find it to be 11 deg. 18 min. which I ſubſtract from 56 deg. 46 min. and the remains is 45 deg. 28 min. Therefore I ſay in that part of the Earth which is 45 deg. 28 min. to the Eaſtwards of *London*, and in the Latitude of 20 deg. 5 min. (the Declination of the Sun) the Sun is in the Zenith; which in this *Example* happens in a place near the Shoars of the Red-Sea.

Now if you open a pair of Callipper Compaſſes to 90 deg. on the Equinoctial, and place one foot in this point of the Earth thus found, and turn the other foot round about the Earth, all the places that that foot paſſes through ſhall at that time have the Sun in their Horizon.

Or if you open the Callipper Compasses to 80, 70, 60, or 50 degrees, *&c.* and place one foot in that point of the Earth aforesaid, and turn the other foot about; All the places it passes through shall have the Sun elevated above their Horizon 10 deg. if the Compasses were extended to 80. 20 deg. if to 70. 30, if to 60, deg. *&c.*

PROB. XXI.

To know at any given-time, what a Clock it is in any other part of the Earth.

KNow first the Longitude of both your Places; Then bring the Meridian to the degree of Longitude on the Equinoctial your Habitation hath, and turn the Index of the Hour-Circle to the Hour of the Day; Then turn the Meridian to the degree of Longitude on the Equinoctial the Place hath you enquire after; So shall the Hour-Index shew what a clock it is there.

Example.

When it is 53 min. past 8 a clock in the Morning here at *London*, I would know what a clock it is then at *Surat* in the *East-Indies*. The Longitude of *London* I find by the Terrestrial Ball to be 27 deg. and the Longitude of *Surat* 114 deg. 25. min. to the Eastwards of it: Therefore I first bring the Meridian to 27 deg. on the Equator, the Longitude of *London*, and set the Index of the Hour-Circle to 53 min. past VIII a clock: Then I turn the Earth till the Meridian come

to

to 114 deg. 25 min. the Longitude of *Surat*, and find that the Index then points at 11 hours 47 min. in the Afternoon; And that is the Hour of the Day at *Surat* when it is 53 min. paſt VIII a clock in the Morning here at *London*.

PROB. XXII.

The Day of the Month, and the Meridian Altitude of the Sun, given, To find the Elevation of the Pole.

BRing the Index of the movable Rundle to the Day of the Month; Then bring the Meridian to the Sun, and depreſs the Horizon till the Sun ſtands ſo many degrees above it, as is the Meridian Altitude of the Sun; So ſhall the upper edge of the Horizon ſtand at the Degree on the Meridian of the Poles Elevation.

Example.

The Day of the Month is *March* 20; And the Meridian Altitude of the Sun here at *London*, is 42 deg. 25 min. Therefore I bring the Index of the movable Rundle to *March* 20 in the Circle of Months, and turn the Earth till the Meridian ſtands againſt the Sun: Then I depreſs the Horizon 42 deg. 25 min. below the Sun; and look on the upper edge of the Horizon, and find that it ſtands againſt 51 deg. 30 min. on the Meridian. Therefore I ſay the Elevation of the Pole here at *London*, is 51 deg. 30 min. See another way, *Uſe of the Globes*, *Book* 2. *Prob.* 15.

PROB.

PROB. XXIII.

The Day of the Month, and Altitude of the Sun at Eaſt, given, To find the Heighth of the Pole.

BRing the Index of the movable Rundle to the Day of the Month, and by the Day of the month given, find the Declination of the Sun, as by *Prob.* 6. Then elevate the Pole to the complement of the Suns Altitude, and bring the Meridian to the Equinoctial Point *Aries*, and count on the Vertical Circle to the Degree of the Suns Declination: Then bring that Degree to the Equinoctial, and note the Degree it cuts, for its complement to 90 is the Heighth of the Pole.

Example.

The Day of the Month is *May* 10; Therefore I bring the Index of the movable Rundle to *May* 10 in the Circle of Months; and by *Prob.* 6. I find the Declination of the Sun to be 20 deg. 5 min. The Altitude of the Sun at Eaſt is 25 deg. 55 min. which I ſubſtract from 90, and the remains is 64 deg. 5 min. the complement of the Suns Altitude; Therefore I ſlide the Horizon upon the Meridian, till the Pole ſtands 64 deg. 5 min. above the Horizon: Then I bring the Meridian to the Equinoctial Point *Aries*, and number on the Vertical Circle 20 deg. 5 min. (the Declination of the Sun) and bring that degree to the Equinoctial, and find the Vertical Circle cut the Equinoctial in 38½ deg.

deg. which I ſubſtract from 90, and the remains is $51\frac{1}{2}$ deg. which is the Elevation of the Pole.

The Declination and Elevation is alwayes of the ſame Denomination either North or South; for when they alter their Denomination, the Sun at the Eaſt can have no Altitude, neither can it indeed reach the Eaſt Point: And therefore in this *Example*, becauſe the Declination of the Sun is North, it is the North Pole that is elevated.

PROB. XXIV.

How to find the true Places of all the Stars on the Sphere. Together with their Longitude and Latitude.

ROund about the Plain of the Ecliptick, is placed ſeveral of the moſt eminent fixed Stars, according to their Longitudes in the Ecliptick: And along the two Semi-Circles of Latitude, is placed the ſame Stars according to their Latitudes from the Ecliptick. So that if you would find the true place of any given-Star in the Sphere, Seek the Star firſt in the Ecliptick; Then ſeek the ſame Star on one of the Semi-Circles of Latitude, and bring the edge of that Semi-Circle to the Star on the Ecliptick; So ſhall the Star on the Semi-Circle of Latitude, ſtand in the ſame place and ſcituation on the Sphere, that it doth in Heaven.

Example.

I would find the Scituation of the bright Star in *Lyra*; Therefore examining the Ecliptick, I find a Star with that name adjoyning to it in ♈ 10 deg. 43 min. which is the Longitude of that Star. Then bringing the graduated edge of the Vernal Semi-Circle of Latitude to that Star on the Ecliptick, I run along with my eye on the Semi-Circle of Latitude, and find the ſame name fixed to a Star in 61 deg. 47 min. upwards, which is the Latitude of that Star: And becauſe it is upwards, it ſhewes the Latitude to be North: So that the Star *Lyra* ſtands now on the Sphere to correſpond in Longitude and Latitude with the Star *Lyra* in Heaven.

Again: I take *Procyon*, the little Dog; This Star I ſeek in the Ecliptick, and find it in ♋ 21 deg. 18 min. But this Star is not to be found upon the ſame Semi-Circle of Latitude; or if it were, it could not be brought to uſe, becauſe the Axis of the Earth will not ſuffer this Semi-Circle to paſs the firſt point of *Cancer*: Therefore I bring the Autumnal Semi-Circle of Latitude to *Procyon* on the Ecliptick, and run along that Semi-Circle with my eye, till I meet with *Procyon* thereon, which I find 15 deg. 57 min. below the Ecliptick, which is the Latitude of *Procyon*: And becauſe it is below the Ecliptick, therefore it hath South Latitude: So that the Star *Procyon* ſtands now alſo on the Sphere to correſpond in Longitude and Latitude with the Star *Procyon* in Heaven. And theſe Stars being thus ſcituated, their Riſings, Settings, Culminatings, Altitudes, Azimuths, Right Aſcentions, Declinations, &c. appear as natural by the Earths Diurnal Converſi-

on

on; as by the Diurnal Revolution of the eighth Sphere; As ſhall be ſhewed in their reſpective *Problemes*.

But if you enquire after any Star that is not on the Sphere, you may place it on the Sphere thus: By Tables you muſt know the Longitude & Latitude of the Stars, and with Black-Lead place its Longitude on the Ecliptick, and its Latitude on its proper Semi-Circle of Latitude: Then by bringing the Semi-Circle of Latitude to the mark you made for the Star in the Ecliptick, the mark you made on the Semi-Circle of Latitude ſhall on the Sphere ſtand correſpondent with that Star in Heaven.

PROB. XXV.

To find the Right Aſcention of any Star.

BRing the proper Semi-Circle of Latitude to the Star on the Ecliptick; Then bring the Meridian to that Star on the Semi-Circle of Latitude; And the Degree of the Equator cut by the Meridian, is the Degree of the Right Aſcention.

Example.

I take *Capella*, alias *Hircus*, and bring the Vernal Semi-Circle of Latitude to that Star on the Ecliptick; Then I bring the Meridian to that Star on the Semi-Circle of Latitude, and find the Meridian cut the Equinoctial in 73 deg. 58 min. counted from the Equinoctial Point ♈: Therefore I ſay the Right Aſcention of *Hircus* is 73 deg. 58 min.

PROB. XXVI.

To find the Declination of any Star.

BRing the proper Semi-Circle of Latitude to the Star on the Ecliptick; then bring the Meridian to the Star on the Semi-Circle of Latitude; and the number of Degrees on the Meridian, comprehended between the Equator and the Star, is the Degree of Declination.

Example.

I take *Capella* aforeſaid, and bring the Vernal Semi-Circle to that Star on the Ecliptick: Then I bring the Meridian to that Star on the Semi-Circle of Latitude, and find 45 deg. 40 min. comprehended between the Equator and that Star. And becauſe *Capella* is on the North ſide the Equator; therefore I ſay *Capella* hath 45 deg. 40 min. North Latitude.

PROB. XXVII.

To find the Right Deſcention, and the Oblique Aſcention, and the Oblique Deſcention of any Star in any given-Latitude.

REctifie the Horizon, as by *Prob.* 5. Then bring the proper Semi-Circle of Latitude to the Star on the Ecliptick, and bring ſome part of the Meridian which is under the Meridian to the Star; ſo ſhall the Degree of the Equator cut by the Meridian, be the Degree

Degree of Right Deſcention. If no part of the Meridian under the Horizon will come to the Star, then hath that Star no Right Deſcention in that Latitude.

For the Oblique Aſcention.

Rectifie the Horizon, as by *Prob.5.* Then bring the proper Semi-Circle of Latitude to the Star on the Ecliptick, and turn the Eaſt ſide the Horizon to the Star; So ſhall the Degree of the Equator cut by the Horizon be the Degree of Oblique Aſcention.

For the Oblique Deſcention.

Rectifie the Horizon as by *Prob.5.* then bring the proper Semi-Circle of Latitude to the Star on the Ecliptick, and turn the Weſt ſide the Horizon to the Star; So ſhall the Degree on the Equator, cut by the Meridian, be the Degree of Oblique Deſcention.

PROB. XXVIII.

The Day of the Month, and Hour of the Day or Night, given, To find the Heighth of any Star above the Horizon in any given-Latitude.

REctifie the Horizon and Hour-Index, and bring the Index of the movable Rundle to the day of the Month in the Circle of Months; Then bring the proper Semi-Circle of Latitude to the Star on the Ecliptick; and turn the Earth till the Index of the Hour-Circle come to the Hour of the day; then bring

the Vertical Circle to the Star: So shall the number of degrees on the Vertical Circle at the Star, be the Heighth of that Star.

Example.

April 19, at 11 a clock at Night here at *London*, I would know the Altitude of *Spica Virgo*; Therefore I bring the Index of the movable Rundle to *April* 19, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring the Autumnal Semi-Circle of Latitude to the Star (called, *Spica Virgo*) on the Ecliptick, and turn the Earth till the Index of the Hour-Circle come to XI a clock; Afterwards I seek *Spica Virgo* on the aforesaid Semi-Circle of Latitude, and bring one of the Vertical Semi-Circles to that Star, and find 28 deg. 59 min. of the Vertical Semi-Circle then at the Star. Therefore I say, on *April* 19 at a 11 a clock at Night here at *London*, *Spica Virgo* is elevated above the Horizon 28 deg. 59 min.

PROB. XXIX.

The Day of the Month, given, To find the Time of the Rising and Setting of any Star in any Latitude.

BRing the Index of the movable Rundle to the day of the Month in the Circle of Months, and rectifie the Horizon and Hour-Index; Then bring the proper Semi-Circle of Latitude to the Star on the Ecliptick, and bring the East side the Horizon to the Star;

So

So ſhall the Index of the Hour-Circle ſhew the Hour the Star Riſes.

And if you bring the Weſt ſide the Horizon to the Star, the Index of the Hour-Circle ſhall ſhew the Hour that Star Sets.

Example.

May 10 here at *London*, I would know when *Spica Virgo* Riſes. Therefore I bring the Index of the movable Rundle to *May* 10 in the Circle of Months, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring the Autumnal Semi-Circle of Latitude to the Star *Spica Virgo* on the Ecliptick, and turn the Earth till the Eaſt ſide the Horizon comes to the Star on the aforeſaid Semi-Circle of Latitude: Then looking in the Hour-Circle, I find the Index point to IIII Hours, and almoſt half a quarter after Noon; which is the time *Spica Virgo* Riſes.

To know when it Sets, I bring the Weſt ſide the Horizon to the Star, and find the Index of the Hour-Circle point to VIII a clock in the Morning within half a quarter of an Hour; Which is the time *Spica Virgo* Sets.

PROB. XXX.

To know what Stars neither Riſe or Set in any given Latitude.

THoſe Stars that have greater North Declination than is the Elevation of the North Pole, never Set under that Horizon.

And

And thoſe Stars that have greater South Declination than is the Elevation of the North Pole, never Riſe above that Horizon. As you may try by any Star that hath ſuch Declination. If you rectifie the Horizon, as by *Prob.5.* and ſet that Star in its proper place, as by *Prob.* 25. and then turn about the Horizon; for ſo ſhall the North ſide the Horizon, never Riſe above thoſe Stars that Set not in Northern Latitude, nor the South ſide the Horizon, ever ſink below thoſe Stars that Riſe not in the ſame Latitude.

PROB. XXXI.

To find the Difference of Time between the Riſing and Setting of any two Stars in any given Latitude.

REctifie the Horizon, and ſet the Stars to their proper place; then bring the Eaſt ſide the Horizon to that Star which hath leaſt Longitude, and turn the Index of the Hour-Circle to XII; Then bring the Eaſt ſide the Horizon to the other Star: So ſhall the Index of the Hour-Circle point to the number of Hours that there is difference between the Riſing of thoſe Stars.

To know the Difference of Time between their Setting. Bring the Weſt ſide the Horizon to the Star that hath greateſt Longitude, and the Index of the Hour-Circle to XII; Then bring the Weſt ſide the Horizon to the other Star; And the Index of the Hour-Circle ſhall point to the number of Hours that there is difference of Time between their Setting.

Exam-

Example, For the Difference of Time in their Riſing.

I would know the Difference of Riſing between *Sirius* and *Spica Virgo*. Therefore I rectifie the Horizon, as by *Prob.* 5. and ſet the Stars on the Semi-Circles of Latitude to their proper Places, as by *Prob.* 25. Then (becauſe *Sirius* hath leaſt Longitude) I bring the Eaſt ſide the Horizon to *Sirius* on the Semi-Circle of Latitude; and keeping it there, I turn the Index of the Hour-Circle to XII (it matters not which XII) Afterwards I bring the Eaſt ſide the Horizon to *Spica Virgo* (on the other Semi-Circle of Latitude) and find then the Index of the Hour-Circle point at V Hours, 58 min. which is the number of Hours and Minutes *Spica Virgo* Riſes after *Sirius*.

Example, For the Difference of Time in their Setting.

The Horizon Rectified, and Stars placed as before, I bring the Weſt ſide the Horizon to *Spica Virgo*, becauſe this Star hath greateſt Longitude; and the Index of the Hour-Circle to XII: Then I turn the Weſt ſide the Horizon to *Sirius*, and find the Index of the Hour-Circle to point at VII Hours 18 min. which is the number of Hours and Minutes that *Sirius* Sets after *Spica Virgo*.

PROB. XXXII.

To find the Cosmical Rising and Setting of the Stars.

THe Cosmical Rising of Stars, is their Rising with the Sun. And their Cosmical Setting is their Setting when the Sun Rises; As I told you in the *use of the Globes*, Book 2. Prob. 35. So that that Sign the Sun is in Rises Cosmically. Therefore seek but the Day of the Month in the Circle of Months, and against it in the Circle of Signs, you have the Sign and degree of the Ecliptick that Rises Cosmically: And the opposite Sign and degree of the Ecliptick, Sets Cosmically. This needs no *Example*.

PROB. XXXIII.

To find the Acronical Rising and Setting of the Stars.

THe Acronical Rising of the Stars, is their Rising when the Sun Sets. And the Acronical Setting, is their Setting with the Sun; As I told you in the *use of the Globes*, Book 2. Prob. 36. so that the Sign opposite to the Sun, Rises Acronically; And the Sign the Sun is in, Sets Acronically. From whence you may perceive, that that Sign that Rises Acronically, Sets Cosmically. And that Sign that Sets Acronically, Rises Cosmically.

PROB.

PROB. XXXIV.

To find the Heliacal Riſing and Setting of the Stars.

WHen a Star formerly in the Sun-Beams comes out of the Sun-Beames, it is ſaid to Riſe Heliacally. And

When a Star formerly out of the Sun-Beams, comes into the Sun-Beams, it is ſaid to Set Heliacally.

Now the Stars aforeſaid, to go into the Sun-Beams, or come out of the Sun-Beams ſooner or later, according to their various Magnitudes. For the Rule of which, I refer you to the *Uſe of the Globes*, Book 2. Prob. 37.

But to find the Time that any Star ſhall Riſe Heliacally, Do thus. Rectifie the Horizon, and ſet the Star to its proper place: Then turn the Eaſt ſide the Horizon to the Star, and move the Vertical Circle to and fro in the Weſt, till you can make the number of de-Degrees aſſigned to the Magnitude of the Star counted on the Vertical Circle below the Horizon, lie in the Ecliptick. Then ſee what Degree of the Ecliptick the Vertical Semi-Circle cuts; for when the Sun comes to the oppoſite Degree of the Ecliptick, that Star ſhall Riſe Heliacally.

Example.

I would know when *Cor Leonis* ſhall Riſe Heliacally here at *London*. Therefore I rectifie the Horizon, as by *Prob.* 5. and ſet the Star in its proper place, as by

Prob. 25. and bring the Eaſt ſide the Horizon to that Star on the Semi-Circle of Latitude; and keeping the Horizon in this poſition, I move the Vertical Circle to and fro on the Weſt ſide the Horizon, till I can fit 12 deg. of it; becauſe *Cor Leonis* is a Star of the firſt Magnitude, counted from the Horizon downwards, to lye in the Ecliptick. Then I examine what Degree of the Ecliptick that Vertical Semi-Circle cuts, and find it to be 9 deg. of *Piſces*. Now the Degree of the Ecliptick, oppoſite to *Piſces* 9. is *Virgo* 9. Therefore when the Sun comes to *Virgo* 9 deg. which by *Prob.* 4. is *Auguſt* 23. *Cor Leonis* ſhall Riſe Heliacally.

For the Heliacal Setting of the Stars.

Rectifie the Horizon, and ſet the Star in its proper place; then bring the Weſt ſide the Horizon to the Star, and move the Vertical Circle to and fro in the Eaſt, till you can make the number of degrees (aſſigned to the Magnitude of your Star) counted on the Vertical Circle above the Horizon, lye in the Ecliptick: Then ſee what Degree of the Ecliptick the Vertical Semi-Circle cuts; for when the Sun comes to the oppoſite Degree of the Ecliptick, that Star ſhall riſe Heliacally.

Example.

I would know when *Bilanx*, a bright Star in the Beam of the Scales, will ſet Heliacally here at *London*. Therefore I rectifie the Horizon, as by *Prob.* 5. And ſet the Star in its proper place, as by *Prob.* 25. and bring the Eaſt ſide the Horizon to that Star on the Semi-Circle of Latitude: And keeping the Horizon in this poſition,

ſition, I move the Vertical Semi-Circle to and fro on the Eaſt ſide the Horizon, till I can fit 13 deg. of it, becauſe *Bilanx* is a Star of the ſecond Magnitude, counted from the Horizon upwards to lie in the Ecliptick. Then I examine what Degree of the Ecliptick that Vertical Semi-Circle cuts, and find it to be ♉ $4\frac{1}{2}$. Now the Degree of the Ecliptick oppoſite to ♉ $4\frac{1}{2}$. is ♏ $4\frac{1}{2}$: Therefore when the Sun comes to ♏ $4\frac{1}{2}$ deg. which, by *Prob.* 4. is *October* 18. *Bilanx* ſhall ſet Heliacally.

PROB. XXXV.

The Meridian Altitude of any Star, given, To find the Heighth of the Pole.

SEt the Star in its proper place, then bring the Meridian to the Star, and move the Horizon upwards or downwards, and the Vertical Circle to or fro, till the Star be elevated on the Vertical Circle above the Horizon the ſame number of Degrees it hath in Heaven; So ſhall the number of Degrees intercepted between the Horizon and the Pole, be the Elevation of the Pole.

Example.

Spica Virgo is obſerved to have 28 deg. 59 min. Meridian Altitude here at *London*: Therefore I place *Spica Virgo* in its proper place, as by *Prob.* 25. And bring the Meridian to that Star on its proper Semi-Circle of Latitude. Then I elevate or depreſs the Horizon, and

move the Vertical Circle to or fro till I can make 28 deg. 59 min. of the Vertical Circle, counted from the Horizon upwards, to lye juſt under *Spica Virgo*: Then counting the number of Degrees between the Pole and the Horizon, I find them 51½ deg. Therefore I ſay the Elevation of the Pole here at *London*, is 51½ degrees.

See an Exception to this Rule in *Uſe of the Globes*, Book 2. Prob. 17.

Prob. XXXVI.

To find what Degree of the Ecliptick comes to the Meridian with any given-Star.

SEt the Star in its proper place, and bring the Meridian to it; So ſhall the Degree of the Ecliptick cut by the Meridian, be the Degree of the Ecliptick that comes to the Meridian with that Star.

Example.

I would know what Degree of the Ecliptick comes to the Meridian with *Lyra*; Therefore I ſet *Lyra* to its place, as by *Prob.* 25. and bring the Meridian to it, and find *Capricorn* 6 deg. 55 min. cut by the Meridian: Therefore I ſay *Capricorn* 6 deg. 55 min. of the Ecliptick comes to the Meridian with *Lyra*.

PROB. XXXVII.

The Day of the Month, and Hour of the Night, given, To know any remarkable Star you ſee in Heaven in any given-Latitude.

BRing the Index of the movable Rundle to the Day of the Month, and rectifie the Horizon and Hour-Index; Then turn the Earth till the Index of the Hour-Circle come to the Hour of the Night; and obſerve the Altitude of the Star, and what point of the Compaſs it bears on: Then bring the Vertical Circle to the ſame point of the Compaſs, and number on the Vertical Circle the Stars Altitude; Then try with the Semi-Circle of Latitude, what Star you can fit to that Altitude, for that is the Star in Heaven.

Example.

September 5, at 10 a clock at Night here at *London*; I ſee a bright Star in the North-Eaſt 23 deg. above the Horizon. Therefore I bring the Index of the movable Rundle to the Day of the Month in the Circle of Months. and rectifie the Horizon and Hour-Index as by *Prob.* 5. Then I turn the Earth till the Index of the Hour-Circle comes to X a clock at Night; And having obſerved the Star in the North-Eaſt 23 deg. above the Horizon, I bring the Vertical Circle to the North-Eaſt Point on the Horizon; and numbring on the Vertical Circle 23 deg. I try with the Circle of Latitude, what Star comes to 23 deg. on the Vertical Circle

Circle, and find it to be *Hircus*; Therefore I ſay *Hircus* is the Star in Heaven I deſired to know.

PROB. XXXVIII.

To find what Day of the Month any given-Star ſhall at any given-Hour come to any Point of the Compaſs in any given-Latitude.

REctifie the Horizon, and bring the Vertical Circle to the Point of the Compaſs the Star hath; then ſet the Star to its place, and turn the Earth till the Vertical Circle comes to the Star; Then turn the Index of the Hour-Circle to the given-Hour; afterwards turn the Earth till the Index of the Hour-Circle points to XII at Noon; So ſhall the Meridian cut the Degree of the Ecliptick the Sun is in: Then bring the Index of the movable Rundle to that Degree of the Ecliptick in the Circle of Signs, and at the ſame time the Index ſhall alſo cut the Day of the Month in the Circle of Months; on which the given-Star ſhall at the given-Hour, come to the given-Point of the Compaſs.

Example.

I ſee *Hircus* at 10 a clock at Night in the North-Eaſt here at *London*. Therefore I rectifie the Horizon to the Latitude of *London*, as by *Prob.* 5. and bring the Vertical Circle to the North-Eaſt point in the Horizon; Then I ſet *Hircus* to its place, as by *Prob.* 25. and turn the Earth till the Vertical Circle comes to *Hircus*

Hircus on the Semi-Circle of Latitude: Then keeping the Earth in this poſition, I turn the Index of the Hour-Circle to X a clock at Night: Afterwards I turn the Earth back again till the Index of the Hour-Circle point to XII a clock at Noon, and examine where the Meridian then cuts the Ecliptick, and find it to be in 22 deg. of *Virgo*, which is the Degree of the Ecliptick the Sun ſhall be in on the Day ſought for: Therefore by the converſe of *Prob.* 4. having the Degree of the Ecliptick the Sun is in, I find the Day of the Month, Thus. I bring the Index of the movable Rundle to *Virgo* 22 in the Circle of Signs, and find the ſame Index cut in the Circle of Months *September* 5. Therefore I ſay when *Hircus* is in the North-Eaſt at 10 a clock at Night here at *London*, it ſhall be the fifth Day of *September*.

By this *Probleme* the Day of the Month may be found though it were loſt.

Note that the Vertical Circle at the ſame time ſhews the Altitude of *Hircus* to be 23 Degrees above the Horizon.

PROB. XXXIX.

The Day of the Month, and Altitude of any known Star on the Eaſt, or on the Weſt ſide the Horizon, given, To find the Azimuth and Hour of the Night in any given-Latitude.

BRing the Index of the movable Rundle to the Day of the Month in the Circle of Months, and rectifie the Horizon and Hour-Index; then bring

the Star to its place; and if it ſtand on the Eaſt ſide the Horizon in Heaven, bring the Vertical Circle to the Eaſt ſide the Horizon; If it ſtand on the Weſt ſide the Horizon in Heaven, bring the Vertical Circle to the Weſt ſide the Horizon, and move the Earth and Vertical Circle to and fro till you can fit the number of Degrees of Altitude, counted on the Vertical Circle, to the Star; So ſhall the Vertical Circle in the Horizon ſhew the Azimuth; and the Index of the Hour-Circle ſhew in the Hour-Circle the Hour of the Night.

Example.

September 5 here at *London*, I ſee *Hircus* on the Eaſt ſide the Horizon, elevated 23 deg. I would know its Azimuth, and the Hour of the Night. Therefore I bring the Index of the movable Rundle to *September 5*. and rectifie the Horizon and Hour-Index, as by *Prob. 5.* and ſet *Hircus* to its place, as by *Prob. 25.* and becauſe it is on the Eaſt ſide the Horizon, I bring the Vertical Circle to the Eaſt ſide the Horizon of the Sphere, and move it and the Earth to and fro till I can make 23 deg. of it lie under the Star *Hircus* on the Semi-Circle of Latitude; Then looking in the Horizon, I find the Vertical Circle cut it in 135 deg. which is the number of Degrees of Azimuth, counted from the South Point the Horizon that *Hircus* at that time hath in Heaven. And looking on the Index of the Hour-Circle, I find the Index point at X. a clock, which alſo ſhews the Hour of the Night.

PROB. XL.

The Day of the Month, and Azimuth of any known Star, given, To find the Hour of the Night, and Almicantar of that Star.

BRing the Index of the movable Rundle to the Day of the Month, and rectifie the Horizon and Hour-Index; then bring the Star to its place, and the Vertical Circle to its known Degree of Azimuth: Then turn the Earth till the Vertical Circle comes to the Star; So shall the Index of the Hour-Circle shew the Hour of the Night; and the Degree of the Vertical Circle cut by the Star, shall be the Almicantar.

Example.

September 5 here at *London*, the Azimuth of *Hircus* is 135 deg. from the South Point on the East side the Horizon. Therefore I bring the Index of the movable Rundle to *Sept.* 5. in the Circle of Months, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring the Vertical Circle to 135 deg. counted from the South Point the Horizon on the East side, and set *Hircus* to its place, as by *Prob.* 25. Afterwards I turn the Earth till the Vertical Circle comes to *Hircus* on the Circle of Latitude; and examining the Index of the Hour-Circle, I find it point to X a clock, which is the Hour of the Night; and I also find 23 deg. of the Vertical Circle lie just under *Hircus* on the Circle of Latitude, which is then the Almicantar of *Hircus*.

PROB. XLI.

To find the Hour of the Night by two Stars in the ſame Azimuth.

BRing the Index of the movable Rundle to the Day of the Month, and rectifie the Horizon and Hour-Index; Then if one of the Stars is placed in the Vernal Hemiſphere, and the other in the Autumnal Hemiſphere, you have no more trouble but to place them in their proper places, and move the Earth and Vertical Circle to and fro, till you can make the Vertical Circle cut both the Stars at once; So ſhall the Index of the Hour-Circle point to the Hour of the Night. But if they both ſtand in the ſame Hemiſphere, *viz.* either in the Vernal or Autumnal, then are they both placed on the ſame Semi-Circle of Latitude: and therefore the Solution will require a double Operation, Thus. Having rectified the Sphere as aforeſaid, ſet one Star to its place; and gueſſing as near the Azimuth as you can, bring the Vertical Circle to the ſame Azimuth on the Horizon; then place the Semi-Circle of Latitude to the ſecond Star on the Ecliptick; and if the Vertical Circle cuts that Star on the Semi-Circle of Latitude alſo, the Index of the Hour-Circle ſhall ſhew the Hour of the Night: But if the Vertical Circle do not cut the ſecond Star, then is the firſt not right placed, and you muſt make another proffer by moving the Earth and Vertical Circle till you can make both the Stars ſucceſſively lie in the ſame Azimuth; So ſhall the Index of the Hour-Circle ſhew the Hour of the Night.

Example.

Example.

December 11 here at *London*, I ſee *Hircus* and *Canicula* in the ſame Azimuth, I would thereby know the Hour of the Night. Therefore I bring the Index of the movable Rundle to *December* 11. and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring both the Stars to their places (becauſe the one is placed on the Vernal, and the other on the Autumnal Hemiſphere) and move the Earth and Vertical Circle to and fro till I can make it cut them both at once; and looking on the Index of the Hour-Circle, I find it point to X a clock, which is the Hour of the Night.

Example, Where both Stars happen in the ſame Hemiſphere.

June 9. I ſee *Cauda Cigni* and *Marchab* in the ſame Azimuth. Therefore I bring the Index of the movable Rundle to *June* 9, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring the proper Semi-Circle of Latitude to *Cauda Cigni* on the Ecliptick, and place the Vertical Circle on the Horizon as near the Azimuth as I can gueſs, and ſo turn the Earth till the Vertical Semi-Circle comes to *Cauda Cigni* on the Semi-Circle of Latitude: Afterwards I move the Semi-Circle of Latitude to *Marchab* on the Ecliptick, (but I keep the Earth in its former poſition) and ſee if the Vertical Circle will then cut *Marchab* on the Semi-Circle of Latitude; if it doth, the *Probleme* is reſolved; if not, I bring *Cauda Cigni* again to its place, and move the Earth and Vertical Circle Northwards or

Southwards according to Judgement, till, when the firſt Star lies in the Vertical Circle, the ſecond Star alſo (ſet to its place) ſhall alſo lye in the ſame Vertical Circle; and then looking in the Index of the Hour-Circle, I find it point to half an hour paſt XI at Night, which is the Time thoſe two Stars lie in the ſame Azimuth on *June* 9.

PROB. XLII.

To find the Hour of the Night by two Stars in the ſame Almicantar.

BRing the Index of the movable Rundle to the Day of the Month in the Circle of Months, and rectifie the Horizon and Hour-Index; then if one of the Stars are placed in the Vernal Hemiſphere, and the other in the Autumnal Hemiſphere, you need but place them to their ſeveral places, and move the Earth and Vertical Circle to and fro till you can make the Vertical Circle cut them both in the ſame Degree; So ſhall the Index of the Hour-Circle point to the Hour of the Night.

But if they both ſtand in the ſame Hemiſphere, the ſolution will require a double operation; for then you muſt ſet one Star firſt to its place; and gueſſing at the Almicantar, turn the Earth and Vertical Circle till you can make that Star ſtand above the Horizon ſo many Degrees as you gueſs it to be in Heaven: Then ſet the ſecond Star to its place, and keeping the Earth ſteddy, try if the ſame Degree of the Vertical Circle cuts that Star alſo, If it doth, the *Probleme* is reſolved by the Index of the Hour-Circle. But if the ſame Degree

of

of the Vertical Circle do not cut that Star alſo, then did you not gueſs aright at the Altitude of the firſt Star; and therefore you muſt make another proffer by bringing the firſt Star again to its place, and moving the Earth or Vertical Circle, or both, till the firſt Star have ſuch an Elevation above the Horizon, as will agree with the ſecond, for then the Index of the Hour-Circle reſolves the *Probleme*, as before.

Example.

January 1 here at *London*, I ſee *Sirius* and *Cor Leonis* in the ſame Almicantar. Therefore I bring the Index of the movable Rundle to *Jan.* 1. and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I bring the proper Semi-Circle of Latitude to *Sirius* on the Ecliptick, and move the Earth and Vertical Circle to and fro till I can joyn ſo many Degrees of the Vertical Circle above the Horizon to *Sirius* as I gueſs it ſtands above the Horizon in Heaven: Then I keep the Earth in this poſition, and ſet the Semi-Circle of Latitude to *Cor Leonis* on the Ecliptick; and alſo examine the Altitude of that Star on the Semi-Circle of Latitude; but if it doth not agree with the Altitude of *Sirius*, then was the Altitude of *Sirius* wrong gueſſed at; and therefore I make another gueſs at their Altitudes, and try again as before, till I make their Altitudes agree; And then looking in the Index of the Hour-Circle, I find it point to IX a clock, which is the Hour of the Night *Sirius* and *Cor Leonis* are in the ſame Almicantar on *January* 1.

PROB. XLIII.

The Day of the Month, given, To find the Hour of the Night, by the Riſing, Culminating, or Setting of any Star.

BRing the Index of the movable Rundle to the Day of the Month, and rectifie the Horizon and Hour Index; then ſet the Star in its place, and if it be juſt Riſing, bring the Eaſt ſide the Horizon to it; If it be Culminating, bring the Meridian to it; If it be Setting, bring the Weſt ſide the Horizon to it; So ſhall the Index of the Hour-Circle point to the Hour of the Night.

Example. For a Riſing Star.

January 1 here at *London* I ſee *Sirius* Riſing. Therefore I bring the Index of the movable Rundle to *Jan.* 1 in the Circle of Months, and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then I ſet *Sirius* to its place, as by *Prob.* 25. and turn the Earth till the Eaſt ſide the Horizon comes to *Sirius* on the Circle of Latitude, and find the Index of the Hour-Circle point to VI Hours 33 min. paſt Noon, which is the time of the Night when *Sirius* Riſes.

Example,

Example. For the Culminating.

Having rectified the Index of the movable Rundle, the Horizon and Hour-Index, and alſo the Star, as before, I bring the Meridian to *Sirius*, and then find the Index of the Hour-Circle point to XI hours 5 min. which is the Time from Noon that *Sirius* Culminates.

Example. For the Setting.

Having rectified the Index of the movable Rundle, the Horizon and Hour-Index, and alſo the Star, as before, I bring the Weſt ſide the Horizon to *Sirius*, and then find the Index of the Hour-Circle point to III Hour 37 min. paſt Midnight; which is the Time that *Sirius* Sets.

PROB. XLIV.

The Day of the Month, and Hour of the Night, given, To find the Heighth of the Pole by a known Star, obſerved Riſing or Setting.

BRing the Index of the movable Rundle to the Day of the Month, and rectifie the Hour-Index; Then ſet the Star to its place, and turn the Earth till the Index points to the Hour of the Night; then move the Horizon upwards or downwards, till the Eaſt ſide the Horizon, if the Star Riſe, or the Weſt ſide the Horizon, if the Star Sets, comes to the Star on the Semi-Circle of Latitude; So ſhall the Horizon cut

on the Meridian, the Degree of the Poles Elevation.

Example.

Here at *London*, *January* 1, about a quarter past 7 a clock at Night, I see *Cor Leonis* Rising, I would thereby know the Elevation of the Pole. Therefore I bring the Index of the movable Rundle to *Jan.* 1. in the Circle of Months, and rectifie the Hour-Index, as by *Prob.* 5. Then I bring the Vernal Semi-Circle of Latitude to the Star *Cor Leonis* on the Ecliptick, and turn the Earth till the Index of the Hour-Circle points to a quarter past VII at Night; then I keep the Earth steady in this position, and move the Horizon upwards or downwards, till the Eastern side of it (because *Cor Leonis* Rises) stands just under *Cor Leonis* on the Semi-Circle of Latitude; and examine what Degree of the Meridian the Horizon cuts, and find 51½ from the North Pole; Therefore I say the North Pole is elevated 51½ deg. here at *London*.

PROB. XLV.

The Age of the Moon, given, To find her Place in the Ecliptick, according to her mean Motion on any given-Day.

BRing the Index of the movable Rundle to the Day of the Month; So shall the Moons Age on the outmost verge of the movable Rundle stand against the Sign and Degree the Moon is in.

Example.

Example.

March 30. 1664. the Moon is 13 dayes old. Therefore I bring the Index of the movable Rundle to *March* 30. and examine in the Circle of the Moons Age on the outmoſt Verge of the movable Rundle, what Degree of the Ecliptick ſtands againſt 13. and find it to be ♎ 8. which is the Sign and Degree the Moon is in that Day at Noon, according to her mean motion.

To find the Age of the Moon.

You muſt remember that the Epact begins with *March*, which muſt be here accounted the firſt Month; Therefore if you add to the Epact the number of the Month current, and the number of the Day of the Month current, the Sum or exceſs above 30. is the Moons Age.

Example.

March 30. 1664. the Epact this Year is 12. *March* is the 1 Month, and the Day of the Month is 30. theſe three numbers added together, makes 43. out of which 30 ſubſtracted, leaves 13 for the Dayes of the Moons Age, *March* 30. 1664.

Theſe Rules may ſometimes fail ſome few Degrees of Truth, becauſe they are only made for the mean Motion of the Moon; yet may they ſerve well enough for many common Operations.

PROB. XLVI.

The Day of the Month, and place of the Moon, given, To find the Time of the Moons Riſing and Setting, and the length of a Moon-ſhine Night.

BRing the Index of the movable Rundle to the day of the Month, and rectifie the Horizon and Hour-Index, then ſet a mark with Black-lead at the Moons Place in the Ecliptick, and turn the Earth till the Eaſt ſide the Horizon comes to that mark; So ſhall the Index of the Hour-Circle point to the Hour of the Moons Riſing. Then turn the Earth till the Weſt ſide the Horizon comes to the mark; So ſhall the Index of the Hour-Circle point to the Hour of the Moons Setting. Then ſubſtract the Hours of the Moons Riſing from 12. and to the remainder add the Hours of the Moons Setting; and the ſum ſhall be the length of Moon-ſhine.

Example.

March 30. 1664. the Moon is in 8 deg. of ♎. I would know when ſhe Riſes here at *London*. Therefore I bring the Index of the movable Rundle to *March* 30. and rectifie the Horizon and Hour-Index, as by *Prob.* 5. Then with a Black-Lead Penſil, I make a mark at 8 deg. of ♎ on the Ecliptick, to repreſent the Moon. Afterwards I turn the Earth till the Eaſt ſide the Horizon comes to that Mark; and looking in the Hour-Circle,

Circle, I find the Index point to one quarter of an Hour paſt V in the Evening, which is the Time the Moon Riſes.

To know when ſhe Sets, I turn the Earth till the Weſt ſide the Horizon comes to the Mark made in the Ecliptick to repreſent the Moon, and look in the Hour-Circle, and find the Index point to three quarters paſt VI, which is the Time in the Morning the Moon Sets.

To know how long the Moon will ſhine, I ſubſtract 5 hours 1 quarter from 12. and the remain is $6\frac{3}{4}$. to which I add $6\frac{3}{4}$. which makes 13 hours and a half for the number of Hours the Moon ſhines *March* 30. 1664 here at *London*.

PROB. XLVII.

How Eclipſes are demonſtrated by the Sphere.

You muſt know that the Moon moves not conſtantly in the Ecliptick, as the Sun ſeems to do, for if ſhe did, there would two Eclipſes happen every Month; the one of the Sun, and the other of the Moon, but ſhe moves in a Circle oblique to the Ecliptick about 5 deg. even as the Ecliptick is oblique to the Equinoctial $23\frac{1}{2}$ deg. And as the Ecliptick cuts the Equinoctial only in two oppoſite points, *viz.* in ♈ and ♎; So the Circle of the Moon cuts the Ecliptick only in two oppoſite points, which are called, *The Dragons-Head* (thus charactered ☊) and the *Dragons-Tail* (thus charactered ☋) That Point which interſects the Ecliptick on the Eaſtern ſide, and proceeds Northwards, is called the *Dragons-Head*; and the oppoſite Point, the *Dra-*

gons-Tail. Theſe Points conſtantly ſhift their places, and have a Retrograde motion through the Ecliptick in almoſt 19 years: And when the Sun and Moon meet in or near either of theſe Points, or oppoſe each other in or near theſe Points, an Eclipſe happens; If they meet, the Sun is Eclipſed, becauſe the dark ſolid Body of the Moon, interpoſes between our ſight and the Sun, and ſo hides him: If they oppoſe each other, the Moon is Eclipſed, for then the dark ſolid Body of the Earth, interpoſes between the Sun and the Moon, and ſo hinders the light of the Sun from falling upon the Moon, which hath no light of its own but what it receives from the Sun.

But that you may more plainly ſee the Demonſtration of Eclipſes; Take the general Sphere (for the particular hath not an Orb for the Moon) and place the little round Ball repreſenting the Moon, in ſuch a Point of the Ecliptick, as from the little round Ball repreſenting the Earth, it may appear directly oppoſite to the little Golden Ball repreſenting the Sun; So ſhall the Sun, the Earth and the Moon be all in a ſtraight line, and the Moon Eclipſed; becauſe the Earth lying directly between the Sun and the Moon, keeps the light of the Sun off the Moon, and ſo becomes a ſhadow to her, which of her ſelf hath no light but what ſhe receives from the Sun, as was ſaid before; and the Moon will continue darkned, till ſhe come out of the Earths ſhadow.

Again, if you place the Moon in the ſame Sphere, ſo as from the Earth ſhe ſhall appear in the ſame Sign and Degree the Sun doth; and imagine, as before, a light to come from that ſmall gilded Ball repreſenting the Sun in the Center of the Sphere; then will you ſee a reaſon why the light of the Sun cannot fall upon the

the Earth, *viz.* becauſe the Moon is interpoſed betwixt the Sun and the Earth, and ſo ſhadows the Earth by keeping the light of the Sun off it, which to us appears as if the Sun were darkned, though indeed it is only the Earth that is deprived of the Suns light by the interpoſition of the Moon, as aforeſaid.

But becauſe an Eclipſe happens not, as was ſaid before, but when the Sun and Moon ſeems to meet or oppoſe one-another in or near the *Dragons-Head* or *Tail*; therefore by the following Rule you muſt learn to find the place of the *Dragons-Head* and *Tail*, that ſo by the Earths and Moons Progreſs through the Ecliptick, you may know when the Sun and ſhe will meet or oppoſe each other in or near thoſe Points, and accordingly fore-know an Eclipſe.

How to find the place of the Dragons-Head *and* Tail.

The *Dragons-Head* and *Tail* finiſhes a Retrograde Revolution through the Ecliptick in 18 years 224 days and 3 hours; So that in one year it moves 19 deg. and 20 min. in a month 1 deg. 36 min. and in one day 3 min. Therefore if for any time paſt or to come, you know the Place of the *Dragons-Head* or *Tail*, you may add or ſubſtract 19 deg. 20 min. for every year, 1 deg. 36 min. for every month, and 3 min. for every day, and the Remainder ſhall be the deg. and min. that the *Dragons-Head* or *Tail* is in.

Example,

Example.

It is to be ſuppoſed that I remember the Place of the *Dragons-Head* to be in ♍ 12 deg. 20 min. I would know the Place of the *Dragons-Head* for this preſent Day, *Auguſt* 2. 1664. Since *January* 1. 1663. there is 1 year, 7 months and 2 dayes paſt: Therefore for the year I allow 19 deg. 20 min. for the 7 months I allow 7 deg. and 7 times 36 min. *viz.* 4 deg. 12 min. more, which makes 11 deg. 12 min. and for the 2 dayes I allow 6 min. which,

19--20
11--12
6 added together, make

30 deg. 38 min.

which ſubſtracted (becauſe the *Dragons-Head* moves contrary to the ſucceſſion of Signs) from ♍ 12 deg. 20 min. leaves ♌ 11 deg. 42 min. for the Place of the *Dragons-Head Auguſt* 2. 1664. The Place of the *Dragons-Tail*, as was ſaid before, is the Degree and Minute of the Ecliptick oppoſite to that of the *Dragons-Head*, which in this *Example* is ♒ 11 deg. 42 min.

PROB.

PROB. XLVIII.

To find by the Sphere when an Eclipſe of the Moon ſhall happen.

EVery Full Moon would ſuffer an Eclipſe, did ſhe not move in a Circle oppoſite to the Ecliptick, as was ſaid in the laſt *Probleme*; but in regard ſhe wanders without the Ecliptick to the obliquity of 5 deg. ſhe is but ſeldom Eclipſed. Now that you may know in which Full Moon ſhe ſhall ſuffer an Eclipſe (for ſhe is never Eclipſed but at a Full Moon) do thus. Find the Suns and Moons Place at Noon for the Day propoſed; if they be oppoſite, or within 10 or 12 deg. of oppoſition to each other, a Full Moon happens that Day; but if they be not oppoſite, you muſt examine their Places in the Ecliptick from Time to Time, till you find them come to *Oppoſition*; when you have found on what Day they will oppoſe each other, and in what Degree of the Ecliptick the Oppoſition will happen, conſider the diſtance of the *Dragons-Head* or *Tail* from the Place of the Oppoſition; for if the *Dragons-Head* or *Tail* be not above 12 deg. diſtant from the Place of Oppoſition, the Moon ſhall be Eclipſed.

Example.

In *July* this preſent Year, 1664. I examined from day to day the Place of the Sun by *Prob.* 4. and Moon by *Prob.* 46. till I found that on the 27th day at Noon, they wanted but a little more than 5 d. to come to Oppoſition of each other; Wherefore I knew that on that

day an Oppoſition or Full Moon would happen; I found alſo by *Prob.* 4. as aforeſaid, the Suns Place in ♌ 15. and the Moons Place by *Prob.* 46. in ♒ 15. at the time of Oppoſition: Then I examined by the Rule in the laſt *Probleme*, the Place of the *Dragons Head*, and found it in 12 deg. of ♌, which is within leſs than 3 deg. of the Place of the Full Moon; Therefore I conclude that Full Moon ſhall be Eclipſed.

And becauſe I found the Moons Place at Noon to be in ♒ 9 deg. and her Place at Oppoſition near 15 deg. which is near 6 deg. more: Therefore accounting 2 Hours for every Degree of her Motion, I ſay that near 12 a clock after Noon, *viz.* 12 a clock at Night, this Eclipſe ſhall happen.

PROB. XLIX.

To find by the Sphere when an Eclipſe of the Sun ſhall happen.

THe Reaſon I ſhewed you in the begining of the laſt *Probleme* why the Moon is not Eclipſed every Full Moon, is the ſame why the Sun is not Eclipſed every New Moon; But as the Moon is only Eclipſed in an Oppoſition to the Sun, ſo the Sun is only Eclipſed in a Conjunction with the Moon. Now to know in what Conjunction an Eclipſe of the Sun ſhall happen, you muſt examine the Latitude of the Moon, (as by the next *Probleme*) at the time of the Conjunction: And if the Latitude exceed the Semi-Diameters of the Sun and Moon, which together are 31 degrees, there will be no Eclipſe.

The

The *Precept* and *Example* I gave you in the laſt *Probleme*; for finding what day the Oppoſition falls on, is ſufficient to find what Day the Conjunction falls on, the Operation being with the one and the other altogether alike.

PROB. L.

The Moons Place, and the Place of the Dragons-Head *or* Tail, *given, To find the Moons Latitude.*

TO reſolve this *Probleme*, you muſt make the Horizon repreſent the Circle of the Moons Way. Thus; Find the Degree of the Ecliptick that ſtands equally between the *Dragons-Head* and *Tail*, and bring one of the Circles of Latitude to that Degree, Then count on the Circle of Latitude 5 deg. upwards; and fit the Horizon, ſo as when it interſects the Place of the *Dragons-Head* and *Tail*, it may ſtand elevated on the Semi-Circle of Latitude 5 deg. Keep the Horizon in this poſition, and bring the Semi-Circle of Latitude to the Moons Place in the Ecliptick; So ſhall the Arch of the Semi-Circle of Latitude, comprehended between the Ecliptick and Horizon, be the Arch of the Moons Latitude.

Example.

Auguſt 21. 1664. the Moons Place is ♒ 29. 43. and the Place of the *Dragons-Head* is ♌ 10. 39. I would know the Moons Latitude; If the Place of the *Dra-*

gons-Head be ♌ 10. 39. the Place of the *Dragons-Tail* muſt be ♒ 10. 39. and the Degree of the Ecliptick that ſtands in the middle between them, is ♏ 10. 39. Therefore I bring the Circle of Latitude to ♏ 10. 39. and count thereon upwards 5 deg. and by moving the Horizon on the Meridian, and turning it to or fro on the Axeltree of the Earth, I fit it ſo, that the outer edge of it ſhall interſect ♌ 10. 39. and ♒ 10. 39. in the Ecliptick, and the fifth Degree of the Circle of Latitude all at once: Then keeping the Horizon ſteady in this poſition, I bring the Semi-Circle of Latitude to the Moons Place in the Ecliptick, *viz.* to ♒ 29. 43. and counting what Degree of the Semi-Circle of Latitude the Horizon then cuts, I find 2 deg. 36 min. Therefore I ſay the Moons Latitude, *Auguſt* 21. 1664. is 2 deg. 36 min.

PROB. LI.

Of the Preceſsion of the Equinoctial.

I Have already ſhewed that the Diurnal Motion of the Earth is a turning towards the Sun, till the Earth make a Revolution upon its own Axis, through all the Degrees of the Equator: And the Annual Motion of the Earth is a turning about the Sun till it hath wholly encompaſſed it, and in that Motion hath turned every Degree of the Equator upon the Axis of the Ecliptick towards the Sun at Noon; whereby it appears that the Equinoctial performs 365 Revolutions towards the Sun in one year; beſides one about the Sun in the ſame time.

But there is yet another Yearly Motion of 48 Seconds,

conds (according to Mr. *Street*) attributed to the Equinoctial, which Dr. *Gilbert* will have depend upon the Earths Magnetick Poles; which Motion is not contiguous to the Earth; but by the Conſequences of his Aſſertion, only inherent to the Magnetick Sphere of the Earth.

This Motion is called, *The Preceſſion of the Equinoctial*, and might aptly be repreſented by the Sphere, in caſe it had a movable Equinoctial, ſo fitted, that it might ſlide through the fixt Equinoctial; for then if for every Revolution of the Earth about the Sun, you move the movable Equinoctial 48 Seconds backwards from the Equinoctial Colure, contrary to the ſucceſſion of Degrees, you would find that in an hundred Revolutions of the Earth (as aforeſaid) the movable Equinoctial ſhould be receded 1 deg. 20 min. from the Equinoctial Colure; and for two hundred Years, 2 deg. 40 min. and ſo proportionably the movable Equinoctial would finiſh a Revolution about the fixt Equinoctial in 27000 years.

This Preceſſion of the Equinox, cauſed the Antients to conceive a Motion in the Starry Heaven, to be performed from Weſt to Eaſt upon the Poles of the Ecliptick; becauſe that by their Obſervations, they found the Stars alter their Places from the Equinoctial Colure: But ſuch a double Motion is not only improbable, but impoſſible in Nature, who delights both in eaſe and uniformity.

PROB. LII.

Of Tides: And how by helping of the Sphere, you may in general judge of them.

DIvide the Equinoctial of the Sphere from the interſection of *Aries* into 30 equal parts; or which is all one, mark every 12 degrees of the Equator with 1, 2, 3, to 30, with Red-Ink; So ſhall thoſe 30 Diviſions repreſent the 30 dayes of the Moons Age.

Then on the North and South Points of the Compaſs on the outmoſt Verge of the Horizon, write with Red-Ink 12 from the North Eaſtwards; *viz.* at the Point North and by Eaſt, write $11\frac{1}{4}$. at the next Point to that, the ſame way, *viz.* North North-Eaſt, write $10\frac{1}{2}$. at the next, *viz.* North-Eaſt and by North, write $9\frac{3}{4}$. and ſo forward to every Point of the Compaſs, rebating of the laſt Hour $\frac{1}{4}$. till you come to 12 in the South, where you muſt begin again to mark that half the Horizon alſo in the ſame order you did the laſt. In this Circle is then repreſented the Points of the Compaſs the Sun and Moon paſſeth by every day, and the Figures annexed, repreſent the twice 12 Hours of the Day and Night.

Having thus prepared the Equinoctial and Horizon, you may by having the Moons age, as by *Prob.* 45. and the Point of the Compaſs, on which the Moon maketh full Sea at any place given, find at what Hour of Day or Night it ſhall be high Tide in the ſame place. Thus.

(It is a known Rule that a North and South Moon makes high water at *Margaret.*) Elevate the Poles of the Horizon into the Poles of the Equinoctial; that is,

is, ſlide the Horizon upwards or downwards, till the Horizon lie juſt in the Equinoctial: Then bring the North or South Points of the Horizon to the Vernal Colure, and count in the Equinoctial the dayes of the Moons age numbred in red Figures; and the Hour and Minute on the Horizon that ſtands againſt the Moons age (alſo writ in red Figures) is the Hour and Minute of high Tide on that Day at *Margaret*.

PROB. LIII.

To find by the Sphere the Variation of the Needle, commonly called, The Variation of the Compaſs.

OBſerve by a Compaſs, whoſe Wyer is placed juſt under the *Flower de luce*, what Point of the Compaſs the Sun Riſes or Sets on Morning or Evening: Then examine by *Prob.* 14. what Degree of the Horizon the Sun Riſes or Sets on by the Sphere alſo; and if the Riſing or Setting be the ſame, both on the Sphere and Compaſs, there is no Variation in your Place. But if there be difference between the Riſing or Setting by the Compaſs and the Sphere, then is there Variation in your Place.

If the Point the Sun Riſes upon in the Compaſs, be nearer the North Point, then the Point the Sun Riſes upon by the Sphere, the Variation is Weſtwards.

If the Point the Sun ſets upon in the Compaſs, be nearer the North than the Point it Sets upon by the Sphere, the Variation is Eaſtwards.

If the Point the Sun Sets upon in the Compaſs, be further

further from the North Point, than the Point the Sun Sets upon by the Sphere, the Variation is Weſtwards.

If the Point the Sun Riſes upon in the Compaſs, be further from the North Point, than the Point the Sun Riſes upon by the Sphere, the Variation is Eaſtwards. And ſo many Degrees as there is between the Point of Riſing or Setting found by the Compaſs, and the Point of true Riſing or Setting found by the Sphere, ſo many Degrees is the Variation from the North towards the Eaſt or Weſt Point.

Otherwiſe, when the Sun hath Altitude.

Having the Altitude of the Sun, find by *Prob.*14. its Azimuth: Then examine by a Compaſs whether the true Azimuth found by the Sphere, agree with the Azimuth found by a Nautical Compaſs; if they agree, there is no Variation: But if the Azimuth of the Compaſs before Noon be nearer the North, than the true Azimuth found by the Sphere, the Variation is Weſtwards.

If the Azimuth by the Compaſs Afternoon, be nearer the North, the Variation is Eaſtwards.

If the Azimuth by the Compaſs Afternoon, be further from the North, the Variation is Weſtwards.

If the Azimuth by the Compaſs before Noon, be further from the North, the Variation is Eaſtwards. And this Variation ſhall be as aforeſaid, ſo many Degrees as there is between the Azimuth obſerved by the Compaſs, and the true Azimuth obſerved by the Sphere.

PROB. LIV.

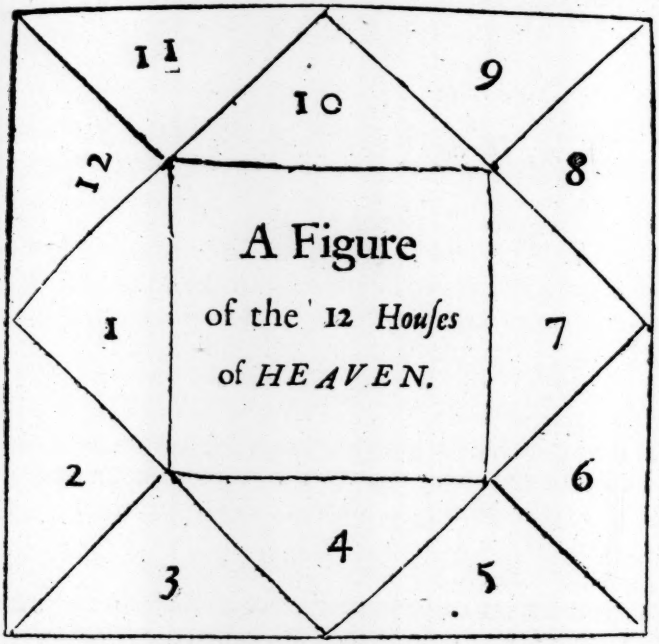
To erect an Astrological Figure of Heaven by the Sphere, for any given-Time.

THe twelve Houſes of Heaven are found by a Semi-Circle of Poſition; which is a Semi-Circle paſſing from the two interſections of the Horizon and Meridian through any Star, Degree, or Point in the Heavens; It is made of Braſs, and divided from the Equinoctial both wayes, with 10, 20, 30, to 90 deg. having at each end a Pin, which muſt be fitted into the two holes of 2 ſtuds fixed in the North and South Points of the upper plain of the Horizon, upon which Pins it is moved up or down according to the Intent of your Operation.

Four of theſe Houſes are named *Cardinals*. The firſt, and moſt eminent of theſe Cardinals, is the firſt Houſe, or the Angle of the Eaſt, called the *Aſcendent*; where the Semi-Circle of Poſition is the ſame with the Eaſtern Semi-Circle of the Horizon.

The ſecond Cardinal is the tenth Houſe, or the Angle of South; called *Medium Cæli*, or *Culmen Cæli*; where the Semi-Circle of Poſition is the ſame with the Semi-Circle of the Meridian above the Horizon. The third Cardinal is the ſeventh Houſe, or the Angle of Weſt; called the *Deſcendent*; where the Semi-Circle of Poſition is the ſame with the Weſtern Semi-Circle of the Horizon.

The Fourth Cardinal is the fourth Houſe, or Angle of North; called *Imum Cæli*; where the Semi-Circle



of Poſition is the ſame with the Semi-Circle of the Meridian under the Horizon.

The Degrees and Minutes of the Ecliptick upon the Cuſps of theſe four Houſes (that is, upon the begining of theſe Houſes) are found all at once; only by bringing the Riſing Degree of the Ecliptick to the Horizon (for the Horizon repreſents the Cuſp of the Aſcendent) and then ſhall the Meridian cut the Degree of the Ecliptick on the Cuſp of the tenth Houſe. The Weſtern Semi-Circle of the Horizon ſhall cut the Degree of the Ecliptick on the Cuſp of the Seventh Houſe: and the Semi-Circle of the Meridian under the

the Horizon, ſhall cut the Degree of the Ecliptick on the Cuſp of the Fourth Houſe.

If you have the Day of the Month, you may by *Prob.* 4. find the Suns Place; and if you have the Hour of the Day, you may by rectifying the Sphere, as by *Prob.* 5. and turning the Earth till the Index of the Hour-Circle point to the ſame Hour in the Hour-Circle, find at the Eaſtern Semi-Circle of the Horizon, the Degree of the Ecliptick that is Riſing, and by conſequence (as aforeſaid) all the Cardinal Points in their reſpective Places.

Now to find what Degree of the Ecliptick occupies the Cuſps of the other eight Houſes of Heaven; do thus; The Sphere rectified, as aforeſaid, move the Semi-Circle of Poſition upwards till 30 degrees of the Equator ſhall be contained between it and the Eaſtern Semi-Circle of the Horizon; ſo ſhall the Semi-Circle of Poſition cut in the Ecliptick, the Degree and Minute of the Ecliptick on the Cuſp of the twelfth Houſe; and its oppoſite Degree and Minute in the Ecliptick, ſhall be the Cuſp of the ſixth Houſe (for you muſt note, that if you have but the Degree and Minute of the Ecliptick upon the Cuſps of ſix of the Houſes, the oppoſite Degrees and Minutes of the Ecliptick, ſhall immediately poſſeſs the Cuſp of every oppoſite Houſe.)

Then move the Circle of Poſition over 30 degrees more of the Equinoctial, ſo ſhall the Degree of the Ecliptick cut by the Circle of Poſition, be the Degree of the Ecliptick upon the Cuſp of the eleventh Houſe, and its oppoſite Degree in the Ecliptick, ſhall be upon the Cuſp of the fifth Houſe. The Degree of the Ecliptick upon the Cuſp of the tenth and fourth Houſes, was found as before. Then remove the Circle

of Poſition to the Weſtern ſide of the Meridian, and let it fall towards the Horizon, till 30 degrees of the Equator are contained between the Meridian and it, ſo ſhall the Degree of the Ecliptick cut by the Semi-Circle of Poſition, be the Degree of the Ecliptick on the Cuſp of the Ninth Houſe; and the oppoſite Degree of the Ecliptick ſhall be upon the Cuſp of the third Houſe. Let the Semi-Circle of Poſition fall yet lower, till it paſs over 30 degrees more of the Equator, ſo ſhall the Degree of the Ecliptick cut by the Semi-Circle of Poſition, be the Degree of the Ecliptick on the Cuſp of the eighth Houſe; and the oppoſite Degree of the Ecliptick, ſhall be upon the Cuſp of the ſecond Houſe. The Degrees of the Ecliptick on the Cuſp of the Seventh Houſe and Aſcendent, were found as before.

Example.

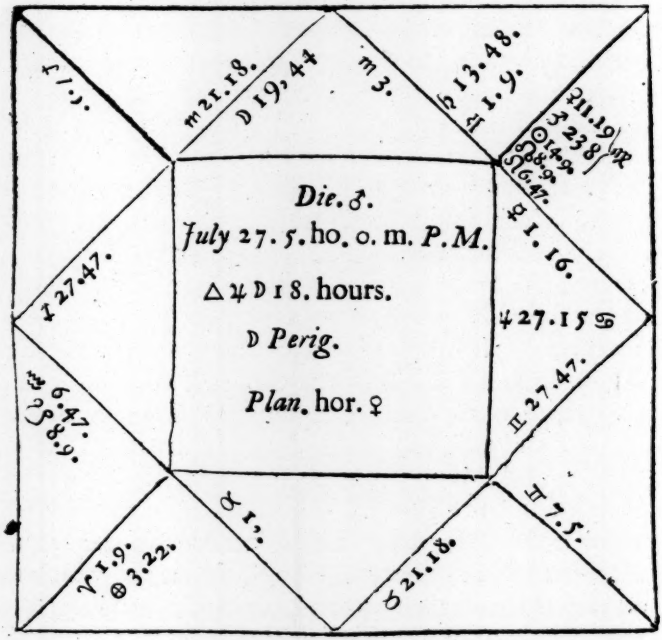
I would erect a Figure of Heaven for *July* 27. 5 hours 0 min. Afternoon, 1658. in the Latitude of *London, viz.* 51½ degrees North Latitude.

I firſt place the Planets, ☉, and ☿ on the Sphere, as by *Prob.* 24. was directed: yet not exactly as I find them in the *Ephemeris*, for that ſhews only their place in the Ecliptick at Noon: Therefore I conſider how many degrees or minutes each Planets motion is in a whole Day, or 24 Hours, by ſubſtracting the Ecliptical degrees and minutes of the Planets Place that Day at Noon, from the Ecliptical degrees and minutes of the Planets Place the next Day at Noon: (or contrarily if the Planet be Retrograde) for the remains of thoſe degrees and minutes, is the motion of the Planet that Day; Therefore proportionably to that motion, I place the Planet forward in the Ecliptick (or backward

ward if it be Retrograde) As if the Sun ſhould move forward 1 degree; that is, 60 minutes in a whole Day, or 24 Hours, then in 12 Hours he ſhould move 30 min. in 6 hours 15 min. in 4 hours 10 min. in 1 hour 2½ min. and ſo proportionably for any other ſpace of Time; which I conſider before I place the Planets on the Sphere.

Having thus placed the Planets on the Sphere, I Elevate the North Pole 51½ deg. above the Horizon, and find the Suns Place by *Prob.* 4. to be in ♌ 14. deg. 9 min; Therefore I bring the Meridian to ♌ 14 deg. 9 min. on the Ecliptick, and the Index of the Hour-Circle to XII; Then I turn the Earth till the Index point to 5 Hours Afternoon, and examine what Degree of the Ecliptick is at the Aſcendent or Horizon, and find ♐ 27. 47. to which Sign, Degree and Minute ♎ 27. 47. is oppoſite; and therefore, as aforeſaid, upon the Cuſp of the Seventh Houſe, lifting up the Circle of Poſition till it paſs over 30 deg. of the Equator from the Horizon upwards, I find ♐ 7. 5. cut by it in the Ecliptick, which is the Sign, Degree and Minute upon the Cuſp of the twelfth Houſe, and its oppoſite Sign, Degree and Minute, is ♎ 7. 5. which is upon the Cuſp of the ſixth Houſe: Then lifting up the Circle of Poſition again, till it paſs over 30 degrees more of the Equinoctial, I find cut by the Circle of Poſition ♏ 21. 18. which is the Sign, Degree and Minute upon the Cuſp of the eleventh Houſe; and its oppoſite Sign, Degree and Minute is ♉ 21. 18. which is upon the Cuſp of the fifth Houſe: ♏ 3. 20. is at the Meridian, which is the Cuſp of the tenth Houſe; and the Sign, Degree and Minute oppoſite to it, is ♉ 3. 20. which is on the Cuſp of the fourth Houſe. Then taking the Semi-Circle of Poſition off its Poles, I place it on the

Weſt ſide the Meridian, and let it fall towards the Horizon, till it paſs over 30 deg. of the Equator from the Meridian, and find the Circle of Poſition cut the Ecliptick in ♎ 1. 9. which is the Sign, Degree and Minute on the Cuſp of the ninth Houſe; oppoſite to ♎ 1. 9. is ♈ 1. 9. therefore ♈ 1. 9. is upon the Cuſp of the third Houſe: Letting the Circle of Poſition fall yet lower till it paſſes over 30 degrees more of the Equator, I find it cut the Ecliptick in ♌ 6. 47. which is the Sign Degree and Minute upon the Cuſp of the eighth Houſe; and its oppoſite Sign Degree and Minute is ♒ 6. 47. which is upon the Cuſp of the ſecond Houſe.



So

So have you a Figure of the Face of Heaven; which if you have future uſe for, you may ſet down the ſeveral Characters in the proper places of a Figure, as they are ſet down in this Scheme.

PROB. LV.

To find the length of a Planetary Hour.

Strologers divide the Artificial Day (be it long or ſhort) into 12 equal parts, and the Night into 12 equal parts: Theſe parts they call *Planetary Hours*. The firſt of theſe Planetary Hours takes its Denomination from the Planetary Day; and the reſt are named orderly from that Planets, according to the ſucceſſion of the Planetary Orbs: As if it be Munday, that is, the Moons day, the Planet reigning the firſt Hour, ſhall be ☽; the Planet ruling the ſecond Hour, ſhall be ♄; the third Planetary Hour ſhall be ♃; the fourth ♂, the fifth ☉, the ſixth ♀, the ſeventh ☿: Then begin again with ☽ for the eight Planetary Hour, ♄ for the ninth, and ſo through the whole Day and Night, till the Sun Riſe again the next Day.

The length of this Planetary Hour is found by the Sphere; thus: The Sphere rectified, Bring the Eaſt ſide the Horizon to the Sun, and make a prick at that degree of the Equator which the Horizon then cuts: Then bring the Meridian to the Sun, and count the number of degrees of the Equator comprehended between that Prick and the Degree the Horizon is now at; and divide that number of Degrees and Minutes by 6. (becauſe there is 6 Planetary Hours paſt ſince Noon) and the Quotient ſhall ſhew the number of Degrees

Degrees and Minutes that paſs through the Meridian in one Planetary Hour.

Example.

July 27. 1658. I would know the length of the Planetary Hour here at *London*; I Rectifie the Sphere, and bring the Eaſt ſide the Horizon to the Sun, and find 115 degrees of the Equator at the Horizon; at this 115 deg. I make a prick, Then I turn the Meridian to the Sun, and find the Horizon then at 220 deg. of the Equator; Therefore I either count the number of Degrees between the Pricks and the Degree of the Equator the Horizon is at, or elſe ſubſtract the leſſer from the greater; but both wayes I find the Meridian (or Horizon) paſs through 111 degree of the Equator in ſix Planetary Hours: Therefore dividing 111 deg. by 6. I find the Meridian paſs through 18 deg. 30 min. of the Equator in one Planetary Hour: which 18 deg. 30 min. reduced into Time, yeelds 72 min. by accounting for every 15 deg. one Hour, for 1 deg. 4 min. and for half a degree 2 min. of Time, and ſo proportionably; So that the length of a Planetary Hour, *July* 27, is 1 common Hour and 14 minutes here at *London*.

PROB.

Prob. LVI.

The length of a Planetary Hour known, To find what Planet reigneth any given-Hour of the Day, or Night.

THe Sphere rectified, as in the laſt *Probleme*, turn about the Earth till the Index of the Hour-Circle points to the Hour of the Day in the Hour-Circle. Then count the number of degrees comprehended between the Degree of the Equator the Horizon is at and the Prick in the Equator made as in the laſt *Probleme*, and reduce that number of Degrees into minutes of Time, by reckoning 4 minutes of Time for every Degree of the Equator: Reduce alſo the number of Degrees and Minutes of the Equator the Meridian paſſes through in one Planetary Hour into Minutes of Time by allowing (as aforeſaid) 4 minutes for every Degree; and then divide the firſt number by the ſecond, and the Quotient ſhall be the number of Planetary Hours ſince Sun Riſing. Having the number of Planetary Hours ſince Sun Riſing, Reckon the firſt Planetary Hour by the name of that Planet that bears the denomination of the Day; the ſecond Planetary Hour by the Planet ſucceeding that in order; the third by the next in order, and ſo for all the reſt, till you come to the laſt Planet. *viz.* ☽; and then begin again with ♄, and ſo to ♃, *&c.* till you have reckoned ſo many Planets as there are Planetary Hours ſince Morning: and that Planet the number ends on, ſhall be the Planet Reigning that Planetary Hour.

Example.

July 27. 1658. aforeſaid, I would know what Planet Rules at 5 a clock paſt Noon: The length of the Planetary Hour this Day (found by the laſt *Probleme*) is 1 hour 14 min. Therefore (the Sphere rectified) I bring the Index of the Hour-Circle to the Hour of the Day, *viz.* V a clock in the Hour-Circle, and then count the number of Degrees between the Prick made, as by the laſt *Probleme*, and the degree of the Equator the Horizon is at, and find them 187. which I reduce into minutes, by allowing for every degree 4 minutes; and that gives 748 minutes. This 748 minutes I divide by the minutes contained in one Planetary Hour this Day, *viz.* by 72. and find 10 hours 8 min. which ſhews there are 10 Planetary Hours and 8 min. paſt and gon ſince Sun Riſing. Therefore ♂ being the Planet after whoſe name the Day is called, *viz. Die Martis*; ♂ is as aforeſaid the Ruler of the firſt Planetary Hour: From him I count the Planet ſucceeding, which is ☉ for the ſecond Hour; from ☉ I count the Planet ſucceeding; which is ♀ for the third Hour, and ſo on to ☿ and ☽. And then I begin the Round again with ♄, ♃, ♂, and ☉, till I come again to ♀, which is the tenth Planetary Hour ſince Sun Riſing: and the Minutes remaining being 8, ſhews that there is 8 minutes paſt ſince ſhe began to reign.

PROB.

PROB. LVII.

To find Part of Fortune *by the Sphere.*

COunt the number of Degrees and Minutes between the Suns Place, and the Moons Place, begining at the Suns Place, and counting according to the ſucceſſion of Signs till you come to the Moons Place: and having found that number of degrees and minutes, add them to the number of degrees and minures Aſcending, reckoned from the firſt Point of ♈. If the ſum exceed 360. caſt away 360. and the remainder ſhall be the number of Degrees and Minutes from the firſt Point in ♈, in which *Part of Fortune* falls. But if it do not exceed 360. you have already the number of degrees and minutes from the firſt point of ♈ in which you muſt place *Part of Fortune.*

Example.

I would find the Place of *Part of Fortune* for the time of our Figure: I ſeek the two pricks repreſenting ☉ and ☽, and find ☉ in ♌ 14. 9. and ☽ in ♏ 19. 44. therefore counting from the Suns Place to the Moons Place according to the ſucceſſion of Signs, I find 95 degrees 35 minutes contained between them: This 95 deg. 35 min. I add to 267 deg. 47 min. the degree and minute contained between the firſt point of ♈, and the Aſcendent; and they make together 363 deg. 22 min. This exceeds 360. therefore I caſt away 360. and the remains are 3 deg. 22 min. for the Place in the Ecliptick of *Part of Fortune*, reckoned from the firſt Point of ♈.

Therefore this Character ⊕ which represents *Part of Fortune*, I set in its proper place of the Figure, as I did the Planets.

PROB. LVIII.

To find in what Circle of Position any Star, or any Degree of the Ecliptick is.

CIrcles of Position are numbred from the Horizon upwards upon the Vertical Circle placed at the East or West point of the Horizon. Therefore when you would find what Circle of Position any Star or Degree of the Ecliptick is in, Rectifie the Sphere and Vertical Circle, and bring the Vertical Circle to the East or West Point of the Horizon, and lift up the Circle of Position till it come to the Star on the Circle of Longitude set to its place, as by *Prob.* 24. or to the Degree of the Ecliptick proposed; and the number of degrees the Circle of Position then cuts on the Vertical Circle, is the number of the Circle of Position that the Star or Degree of the Ecliptick is in. If the Star or Degree of the Ecliptick be under the Horizon, Turn the Earth till the Meridian pass through 180 deg. of the Equator. And if it be a Star you enquire after, make shift with the other Circle of Longitude; thus, Set it to the opposite Degree of the Ecliptick, and make a prick on it at the degree and minute it hath in the first Circle of Longitude: but in contrary Latitude, As if it be on the South side in the first Circle of Longitude, it must be on the North side on the other Circle of Longitude; then will the prick which represents the Star, or the Degree of the Ecliptick, be above

above the Horizon: Lift up then the Circle of Position (as before) to that prick or degree of the Ecliptick, and the number of degrees the Circle of Position cuts the Vertical Circle at on the East side, is the number of Circles of Position the Star was under the Horizon on the West side; Or so many Degrees as the Circle of Position cuts the Vertical Circle at on the West side the Horizon, is the number of the Circles of Position the Star or Degree of the Ecliptick was under the Horizon on the East side.

PROB. LIX.

How to Direct a Figure by the Sphere.

TO Direct a Figure is to examine how many Degrees of the Equinoctial the Earth moved Eastwards or Westwards, while any Planet or Star in one House comes to the Cusp or any other point of any other House.

When you would Direct any *Promittor* to any *Hylegiacal* point, Examine the Degree of the Equator the Meridian is at; then turn the Earth till the *Promittor* come to the *Hylegiacal* Point, and examine again the Degree of the Equator the Meridian is at; and by substracting the lesser from the greater, you will have the number of Degrees that the Meridian passed through whilst the place of the *Promittor* was brought to the *Hylegiacal* point: and that number of Degrees shall be the Arch of Direction.

Example.

I would Direct the Body of the Moon in our Figure aforeſaid to *Medium Cæli*, or the tenth Houſe: I find by the Sphere the Meridian at 203 deg. 30 min. of the Equator with the tenth Houſe, and turning the Earth till the Meridian come to the prick made to repreſent the Moon, I find the Meridian come to 227 deg. 20 min. of the Equator: Therefore I ſubſtract the leſſer from the greater, *viz.* 203 deg. 30 min. from 227 deg. 20 min. and have remaining 23 deg. 50 min.

This 23 deg. 50 min. ſhews that 23 Years 10 Months, muſt expire ere the Effects promiſed by the Moons preſent Poſition, ſhall operate upon the ſignification of the tenth Houſe.

If the Body of the Moon had been Directed to any other Point than the Meridian or Horizon, you muſt have elevated the Circle of Poſition to the Point propoſed; and have under-propped it to that Elevation, and then have turned about the Earth till the Circle of Poſition had come to the prick repreſenting the Moon, and then the Degrees of the Equator the Meridian ſhould have paſſed through whilſt this Motion was making, ſhould be the number of Degrees of Direction; and ſignifie in Time as aforeſaid.

PROB. LX.

Of Revolutions: and how they are found by the Sphere.

BY Revolution is meant the Annual Converſion of the Sun to the ſame place he was in at the Radix of any Buſineſs. When you would find a Revolution by the Sphere, Firſt find the Right Aſcention of Mid-Heaven at the Radix of the Buſineſs, as by *Prob.* 7. you were directed to find the Right Aſcenſion of the Sun; and to it add 87 degrees for every Year ſince the Radix: Then ſubſtract 360 ſo oft as you can from the whole, and the Remains ſhall be the Right Aſcenſion of Mid-Heaven for the Annual Revolution.

If you count the number of Degrees of the Equator contained between the Right Aſcenſion of the Mid-Heaven, and the Right Aſcenſion of the Sun, and convert that number of Degrees into Time, by allowing for every 15 deg. 1 Hour of Time, it will ſhew, if the Suns Place be on the Weſtern ſide of the Meridian, the number of Hours and Minutes Afternoon the Revolution ſhall happen on; but if on the Eaſt ſide the Meridian, the number of Hours and Minutes before Noon the Revolution ſhall happen on.

PROB.

PROB. LXI.

How a Figure of Heaven may be erected by the Revolution thus found.

SEek the Degree of Right Aſcenſion of Mid-Heaven, and bring the Meridian to it; So ſhall the four Cardinal Points of the Sphere be the ſame with the four Cardinal Points in Heaven at the time of the Revolution. The other Houſes are found by the Circle of Poſition: as in *Prob.* 54.

PROB. LXII.

To make an Equinoctial Dyal in any Latitude.

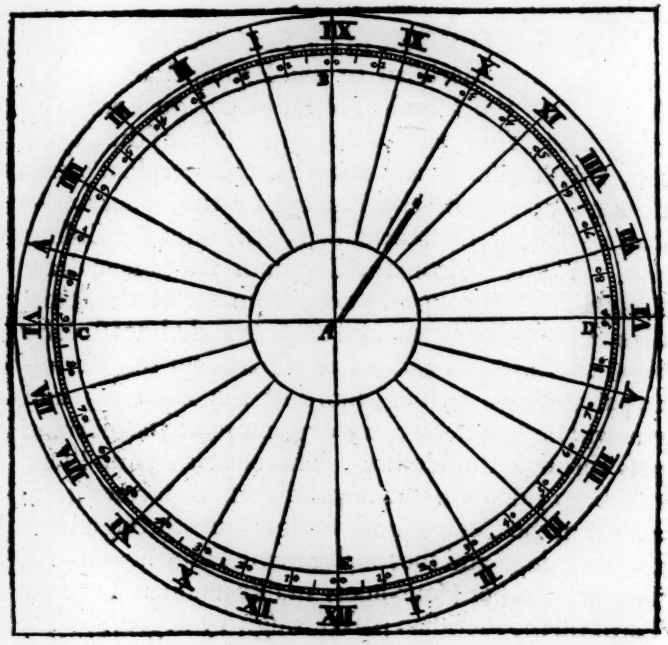
OF Dyal-Planes, and how they may be known; As alſo how to find the Meridian Line on any Plain, I have already written in the *Uſe of the Globes*, *Book* 5. before the *Problemes*; whither, to avoid repetition, I refer you.

Diſcribe a Circle on a ſquare Board or Plane, as B C D E, and through A the Center thereof draw a ſtraight Line parallel to one of the ſides, as B E; Croſs that ſtraight Line with another ſtraight Line, as C D at Right Angles; ſo ſhall the Circle be divided into four equal parts: Divide each of theſe four equal parts into 90 deg. as in the Figure. This Circle ſhall repreſent the Horizon.

Erect a Wyer exactly perpendicular on the Center of the

the Plane; and that Wyer ſhall be the *Gnomon* or *Style* of the Dyal.

Then elevate the Pole of the Earth into the Zenith, and bring the Meridian to the Equinoctial Colure; And becauſe the Meridian of all places on Earth, in every hours Time paſſes through 15 deg. of the Equator, therefore turn the Earth till the Meridian paſſes through 15 deg. of the Equator on the Sphere; So ſhall 15 deg. of the Horizon paſs through the Colure alſo. Therefore from the Center of your Plane draw ſtraight Lines through 15 deg. from one of the Semidiameters both wayes; and thoſe ſtraight lines ſhall be two Hour-lines: Then turn the Earth till the Meridian paſs through 15 deg. more of the Equator; and you will find, as before, 15 deg. more of the Horizon paſs through the Colure: Therefore on your Plane number 15 deg. further beyond both the former lines, and from the Center draw ſtraight lines through both thoſe 15 deg. and they ſhall be two Hour-lines more: For all the other Hour-lines, in like manner, Turn the Earth till the Meridian paſs through 15 degrees of the Equator at a time, as before, and you will find that for every 15 deg. of the Equator which the Meridian paſſes through 15 deg. of the Horizon will paſs through the Colure alſo: Therefore thoſe Hour-lines muſt be drawn from the Center according to the ſucceſſion of every 15 degrees on your Plane. Having drawn the Hour-lines, you may ſet figures to them, begining to number your Hour-lines from one of the Diameters, marking it with XII, and the next Hour-line to the left hand with I, and the next II, the next III, &c. to XII. and begin again with I, II, III, &c. till you come to the other XII, where you began: and then your Dyal is finiſhed. See the Figure.



This is an Univerſal Dyal, and ſerves in all Latitudes: Therefore when you place it, you muſt ſet one of the XII^s downwards, and the Axis parrallel to the Axis of the World.

But note, Both faces of this Dyal ought to be divided, and the *Gnomon* muſt appear on both ſides like the ſtick in a Whirligig which Children uſe; or elſe you muſt turn it upſide down ſo oft as the Sun paſſes the Equinoctial.

PROB.

PROB. LXIII.

To make an Horizontal Dyal.

DIſcribe a Circle on your Plane, as C B D E, and through the Center A of that Circle draw a Meridian or twelve a clock line, as B E; croſs that line at right Angles with another line, as C D; ſo ſhall your Circle be divided into four equal parts: Divide each of theſe four parts into 90 deg. ſo ſhall the whole be divided into 360. Theſe 360 deg. repreſent the 360 deg. of the Horizon, which with the Earth paſs through the Solſticial Colure once in every 24 Hours. This Motion of the Horizon through the Colure is regular in a parallel Horizon, for in equal Time it moves equal ſpace from the Colure (as was ſhewed in the laſt *Probleme*) *viz.* 15 deg. of the Horizon will paſs through the Colure, and 15 deg. of the Equator in one Hours Time: But in an oblique Horizon the Motion of the Horizon is irregular, and that more or leſs according to the obliquity of the Horizon; For far Northwards or Southwards, you may ſee 40, 50, yea 60 deg. of the Horizon paſs through the Colure in one Hours Time, *viz.* whilſt the Horizon paſſes through 15 deg. of the Equator: But in another Hours Time you will ſcarce have 4 or 5 deg. paſs through the Colure whilſt the Horizon moves through 15 deg. of the Equator.

But that you may know the number of Horizontal Degrees that paſs through the Colure in one Hours time in all Latitudes, do thus; Elevate the Horizon to the Elevation it hath in your Place, and bring the Meridian to the Solſticial Colure, and the Index of the

Hour-Circle to XII on the Hour-Circle: Then turn the Earth Eaſtwards till the Meridian paſs through 15 deg. of the Equinoctial; So ſhall the Colure cut the number of degrees and minutes on the Horizon that you muſt place the 1 and 11 a clock lines on the Plane from the 12 a clock line.

Then turn the Earth again Eaſtwards till the Meridian paſs through 15 deg. more of the Equinoctial, So ſhall the Colure cut the number of degrees and minutes on the Horizon that you muſt place the 2 and 10 a clock lines on the Plane from the 12 a clock lines.

Thus for finding the Places of all the other Hour-lines to 6, Morning and Evening you muſt turn the Earth ſtill Eaſtwards till the Meridian paſs through 15 deg. ſucceſſively for every ſucceſſive Hour; So ſhall the Colure cut the number of degrees and minutes on the Horizon that you muſt place the reſpective Hour-lines on your Plane on either ſide the 12 a clock line.

For finding the Hour-lines before 6 in the Morning and after 6 in the Evening (becauſe the longeſt day contains more than 12 hours in all Places that have Latitude from the Equator) you need but lay the edge of a Ruler (that is long enough to reach through the whole Plane) by the ſide of the Morning 7 a clock line, and ſo prolong that line through the Center and other ſide of the Plane, and that prolongation ſhall be the Evening 7 a clock line: The ſame for the eight or nine a clock line, *&c.* if the longeſt Day be ſo long in your Place: And the ſame for the Morning 5, 4, or 3 a clock, *&c.*

Theſe Hour-lines muſt be markt from the Meridian or 12 a clock line A B towards D, with I, II, III, *&c.* till you have numbred to the Hour of Sun-Set found by *Prob.* 16. the longeſt Day, and from the Meridian

ridian line towards C, with XI, X, IX, *&c.* till you have numbred to the Sun-Rising the longeſt Day.

The Stile muſt be placed in the Center of the Plane, and elevated ſo many Degrees above the Plane, as the Pole is elevated above the Horizon of your Place.

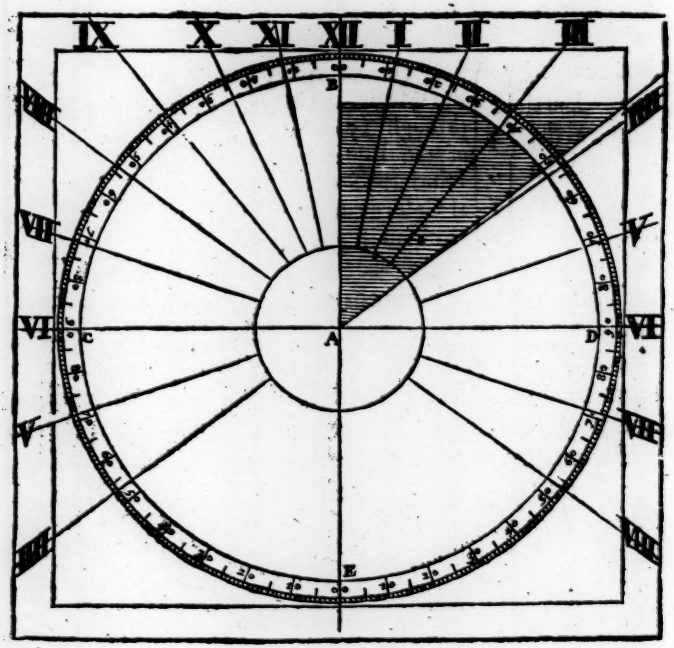
Example of the Whole.

I would make an Horizontal Dyal for *Londons* Latitude: Therefore I elevate the North ſide of the Horizon 51½ deg. and bring the Meridian to the Solſticial Colure, and the Index of the Hour-Circle to XII on the Hour-Circle;

and turning the Earth Eaſtwards, till the Index points to	1	a clock; or till the Merid. paſs through 15 deg. of the Equator. I find the Solſtial Colure cut the Horizon in	11.40	from the Meridian, or South point of the Horizon.
	2		24.15	
	3		38. 4	
	4		53.36	
	5		71. 6	
	6		90.	

Theſe are the diſtances of the 6 Hour-lines before and after Noon: and to theſe diſtances on the Plane, (counting from B towards D on the right hand, and from B towards C on the left hand) I make pricks; and from the Center I draw lines through theſe pricks, and theſe lines are the Hour-lines from XII to VI after Noon, and (counted backwards) from XII to VI before Noon. But the Sun in the longeſt Day ſhines till paſt VIII at Night, as you may find by *Prob.* 16. therefore here wants the two Evening and the two Morning Hour-lines; which though they may be found after the ſame way I found the former (*viz.* by

continuing the turning of the Earth Eaſtwards) yet that I may the ſooner reduce my work to the Plane I count the number of degrees between the V I a clock line and the V a clock line in the Circle on the Plane; for the ſame number of degrees counted from D towards E, and from C towards E, is the diſtance of the VII a clock Hour-line from the VI a clock Hour-line in the Evening, and from the VI a clock line, to the V a clock line in the Morning: And the number of degrees contained between the VI a clock Hour-line and the IV a clock Hour-line, is the number of degrees contained between the VIII a clock Hour-line from



the

the VI a clock Hour-line in the Evening, and from the VI a clock line to the IV a clock line in the Morning. Or laying the edge of a Ruler, as I ſaid before (that will reach through the oppoſite ſide of the Plane) on the Morning VII and VIII a clock Hour-lines, I may by the ſide of that Ruler, draw lines from the Center through the oppoſite ſide of the Plane, and thoſe lines ſhall be the VII and VIII a clock Hour-lines after Noon.

And laying the edge of a Ruler on the Evening V and IV a clock Hour-lines, I may by the ſide of the Ruler, draw lines from the Center through the oppoſite ſide of the Plane; and thoſe lines ſhall be the Morning V and IV a clock Hour-lines.

If you will have the half Hour-lines placed on your Dyal, you muſt turn the Earth till the Index points to every half Hour in the Hour-Circle, as well as to the whole, and examine the degrees of the Horizon cut by the Solſticial Colure, as you did for the whole Hours; and in like manner transfer them to your Plane.

Having thus drawn all the Hour-lines, I count from the Noon line 51½ deg. (the elevation of the Pole here at *London*;) and from the Center A I draw a ſtraight line, as A F through theſe 51½ deg. for the *Gnomon* or *Style*, and prolong it to the fartheſt extent of the Plane: From this *Gnomon* or *Style* I let fall a Perpendicular upon the Noon line, as F G: (this Perpendicular is called the *Subſtile*) and this Perpendicular and its Baſe (which is the Noon line) and *Hypothenuſa* (which is the *Gnomon*) ſhall make a Triangle, which being erected upon the Baſe, ſo as the Subſtile may ſtand Perpendicular to the Plane, the *Hypothenuſa*;

ſo A F ſhall be the *Gnomon*, and be parallel to the Axis of the World, and caſt a ſhadow upon the Hour of the Day.

PROB. LXIV.

To make an Erect Direct South Dyal.

DRaw on your Plane an Horizontal line, as C A D: in the middle of this line (as at A) diſcribe as on a Center the Semi-Circle C B D: from the Center A let fall a Perpendicular, which ſhall divide the Semi-Circle into two Quadrants, each of which Quadrants you muſt divide into 90 deg. Then Elevate the Horizon to the Elevation it hath in your Place, and bring the Meridian to the Solſticial Colure, and the Index of the Hour-Circle to the Hour of XII in the Hour-Circle; So ſhall the Sphere be rectified. Then bring the Vertical Circle to the Eaſt point of the Horizon, and turn the Earth Eaſtwards till the Index points to all the Hours after Noon; and examine in what number of degrees from the Zenith the Colure cuts the Vertical Circle when the Index points to each Hour, for a line drawn from the Center A through the ſame number of degrees reckoned from the Perpendicular A B (which is the XII a clock line) towards D on the Plane, ſhall be the ſame Hour-lines the Index points at.

Thus in our Latitude, *viz.* 51½ deg. the Vernal Colure being brought to the Meridian, and the Index of the Hour-Circle to XII.

If

If you turn the Earth Eaſtwards, till the Index points to

1	a clock, or till	9.18
2	the Meridian paſs	19.15
3	through 15 deg.	32. 5
4	of the Equator	48. 0
5	the Colure will	67. 4
6	cut the Vertical Circle in	90

counted from the Zenith.

And theſe are the diſtances of the Afternoon Hour-lines; which you muſt transfer to the Eaſt ſide of your Plane, *viz.* from B towards D; and draw lines from the Center A through theſe diſtances; and theſe lines ſhall be your Afternoon Hour-lines.

Note (once for all) when that Circle you examine the Hour-diſtances in goes off the Colure, the Sun will ſhine no longer upon that Plane: As in this *Example*, the Vertical Circle goes off the Colure at 6 a clock; therefore the Sun will not ſhine longer than till 6 a clock upon this Plane.

The Hour-lines before Noon have the ſame diſtance from the Meridian that the Afternoon Hour-lines have, as was ſhewed in the laſt *Probleme*; Only they muſt be counted from B towards C, and drawn on the Weſt ſide the Noon line.

Otherwiſe.

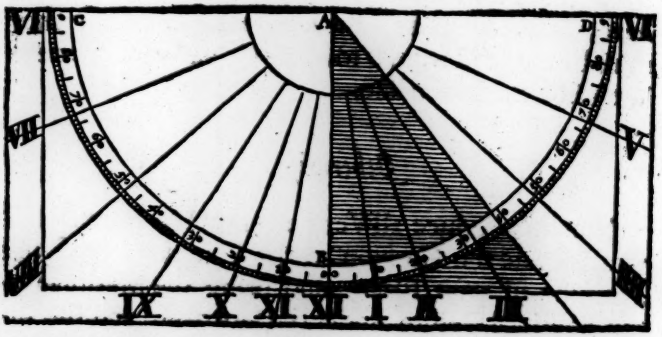
You may reduce all Verticals into Horizontals; if you Elevate the Horizon to the Complement of the Latitude of your Place, and bring the Meridian to the Solſticial Colure under the Horizon, and the Index of the Hour-Circle to XII, and turn the Earth Eaſtwards; for as the Index paſſes through every Hour on the Hour-Circle, the Colure ſhews in the Horizon the diſtance of the ſeveral Afternoon Hour-

lines from the Meridian or XII a clock line, in the Circle on your Plane, numbred from B to D; and lines drawn from the Center through theſe diſtances on your Plane, ſhall be the Afternoon Hour-lines of your Dyal; As you may try by working as you were directed in the laſt *Probleme*.

Example.

Londons Latitude is $51\frac{1}{2}$ deg. its Complement to 90. is $38\frac{1}{2}$. Therefore I elevate the Horizon $38\frac{1}{2}$ degrees above the Equinoctial, and bring the Meridian to the Solſticial Colure under the Horizon, and the Index of the Hour-Circle to XII on the Hour-Circle. Then

Turning the Earth Eaſtwards, till the Index of the Hour-Circle points to	1	a clock, or till the Meridian paſs through 15 deg. of the Equator, I find the Colure cut the Horizon in	9.18	from the interſection of the Meridian and the Horizon: as in the former Table.
	2		19.15	
	3		32. 5	
	4		48. 0	
	5		67. 0	
	6		90.	



And theſe are the diſtances of the 6 Hour-lines from the Meridian.

By

By this *Example* you may ſee that it is eaſie to reduce Verticals into Horizontals, and Horizontals into Verticals: for this Erect Direct South Dyal is an Horizontal Dyal to thoſe People that Inhabite 90 deg. from us, *viz.* in the South Latitude of $38\frac{1}{2}$ degrees.

Then make a Triangle, whereof the Noon line ſhall be Baſe: from it count the Complement of the Poles Elevation, *viz.* $38\frac{1}{2}$ deg. and through them draw the line A F from the Center A, which ſhall be *Hypotenuſa*; Then let fall a Perpendicular upon the Noon line A B, ſo is your Triangle made. If this Triangle be erected Perpendicularly upon the Baſe or Noon line, the *Hypotenuſa* A F ſhall ſtand parallel to the Axis of the World, and caſt a ſhadow upon the Hour of the Day.

PROB. LXV.

To make an Erect Direct North Dyal.

IF the Erect Direct South Dyal were turned towards the North; and the line C A D were turned downwards, and the line marked with 7 be now marked with 5, and the line 8 with 4, the line 5 with 7, and the line 4 with 8, then have you of it a North Erect Direct Dyal.

All the other Hour-lines in this Dyal are uſeleſs, becauſe the Sun in our Latitude ſhines on a North Face the longeſt Day only before 6 in the Morning, and after 6 at Night.

PROB. LXVI.

To make an Erect Direct Eaſt Dyal.

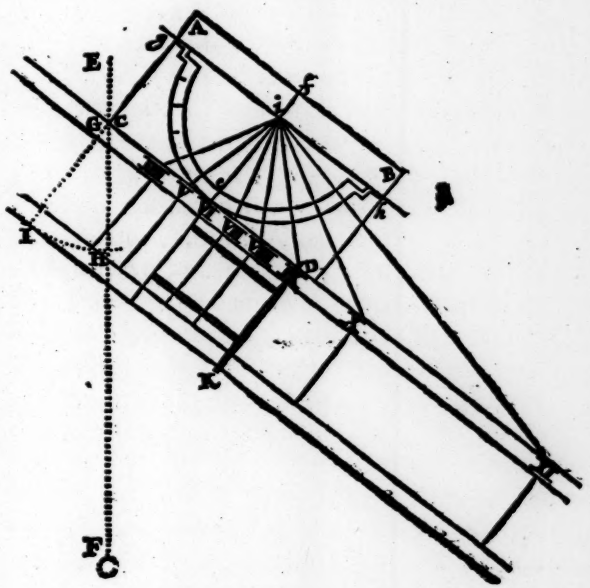
PRovide a ſquare Board, as A B C D, draw the ſtraight line *e f* upon it Parallel to the ſides A C, and B D, and juſt in the middle between them: Croſs this ſtraight line at Right Angles with another ſtraight line, as *g h*, quite through the Board.

Upon this Board with a little Pitch or Wax faſten the Semi-Circle of Poſition, ſo as both the Poles thereof may lie in the line *g h*, and the middle of the Semi-Circle marked oo may lye upon the line *e f*, ſo ſhall *i* be the Center of the Semi-Circle of Poſition: In this Center make a ſmall hole through the Board fit to receive a Wyer or a Nail. So may you with this Circle of Poſition thus fitted, and the ſide C D applyed to a line of Contingence elevated to the Height of the Equinoctial, draw lines from the Center through every 15 deg. of the Circle of Poſition, and by continuing them interſect the line of Contingence in the points from whence the Hour-lines of an Eaſt or Weſt Dyal is to be drawn.

Example.

Example.

I would make an Erect Direct East Dyal for *Londons* Latitude. Therefore I fasten a Plumb-line a little above the place on the Wall where I intend to make my Dyal, and wait till it hangs quietly before the Wall:



then if the line be rub'd with Chalk (like a Carpenters line) I may by holding the Plumbet end close to the Wall, and straining it pretty stiff, strike with it a straight line, as Carpenters do. This line shall be a Perpendicular as E F: I chuse a convenient point in this Perpendicular, as at G, for a Center; whereon I

deſcribe an occult Arch as HI: this Arch muſt contain the number of Degrees of the Elevation of the Equinoctial counted between H and I (which in our Lati- is $38\frac{1}{2}$) Therefore in a Quadrant of the ſame Radius with the occult Arch I meaſure $38\frac{1}{2}$ deg. and ſet them off in the Plane from H in the Perpendicular to I: Then from I to the Center G in the Perpendicular, I draw the prick line I G, and this line ſhall repreſent the Axis of the World: I croſs this Axis at Right Angles with the line G K, and draw it from G to K, ſo long as I poſſibly can: this line ſhall be the Contingent line. I find a convenient place in this Contingent line as at VI, to which I apply the ſide of the Board C *e* D, ſo as that the point *e* may ly juſt upon VI in the Contingent line; And having a thred faſtned in the Center of the Semi-Circle of Poſition, I draw that thred ſtraight over the firſt 15 deg. of the Circle of Poſition, numbred from o towards *b*, and where the thred cuts the Contingent line, I make a mark, for that mark ſhall be the mark for the 7 a clock line. From thence I remove the thred to 30 deg. of the Semi-Circle, and draw it through the Contingent line, and where it cuts the Contingent line, there ſhall be the mark for the 8 a clock line. From thence I remove the thred to 45 deg. of the Semi-Circle, and draw it through the Contingent line, and where it cuts the Contingent line, there ſhall be the mark for the 9 a clock line. From thence in like manner I remove the thred to 60. and 75. and where the thred cuts the Contingent line, ſhall be the mark for 10 and 11 a clock lines: The 12 a clock line cannot be drawn on this Plane, as you may ſee, if you apply the thred to 90 deg. for though you ſhould draw it out never ſo far, yet would it never touch

touch the Contingent line, becauſe it is Parallel to the line *g b*, and lines Parallel never meet.

But becauſe in our Latitude the Sun Riſes before 4 in the Morning, therefore two Hour-lines are yet wanting, *viz.* 5 and 4, which I may find either by applying the thred firſt to 15, and next to 30 deg. from o towards *g* in the Semi-Circle, and ſo marking where it cuts the Contingent line, as before: Or elſe by transferring the diſtance of the ſame number of Hour lines from the 6 a clock line already drawn on the ſide *e h*, to the ſide *e g*, as in *Prob.* 62. of this Book is more fully ſhewed.

Having thus marked out on the Contingent line the diſtances of each Hour; I draw a line Parallel to the Contingent line, and draw lines from every Hour markt on the Contingent to croſs the Contingent line at Right Angles, and continue each line to the line Parallel to the Contingent; and theſe lines ſhall be the Hour-lines of an Eaſt Plane. To theſe Hour-lines I ſet Figures, as in the Scheam may be ſeen.

The *Style* D K of this Dyal (as well as of others) muſt ſtand Parallel to the Axis of the World: it muſt be alſo Parallel to all the Hour-lines, and ſtand directly over the 6 a clock line. and that ſo high as is the diſtance between the Center of the Semi-Circle of Poſition, and the Point where the 6 a clock line cuts the Contingent line: Or (which is all one) at ſuch a height as when it is laid flat down upon the Plane, it may juſt reach the 9 a clock Hour-line.

PROB. LXVII.

To make an Erect Direct Weſt Dyal.

AN Erect Direct Weſt Dyal is the ſame in all reſpects with an Erect Direct Eaſt Dyal; Only as the Eaſt ſhews the Forenoon Hours, the Weſt ſhews the Afternoon Hours.

Thus if you ſhould draw the Eaſt Dyal on any tranſparent Plane, as on Glaſs, Horn, or an Oyled Paper, on the one ſide will appear an Eaſt Dyal, and on the other ſide a Weſt. Only the Figures, as was ſaid before (muſt be changed) for that which in the Eaſt Dyal is 11, in the Weſt muſt be 1: that which in the Eaſt Dyal is 10, in the Weſt muſt be 2: that which in the Eaſt Dyal is 9, in the Weſt muſt be 3, *&c.*

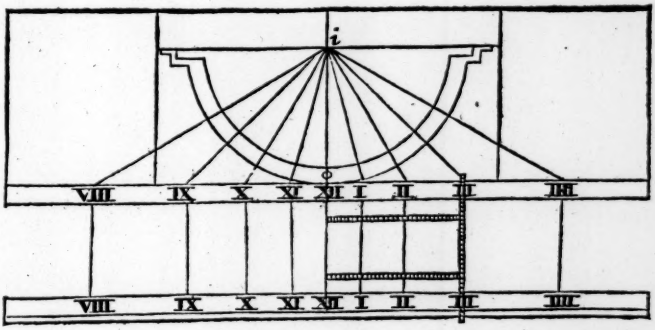
PROB. LXVIII.

To make a Polar Dyal.

POlar Dyals are Horizontal Dyals under the Equinoctial: They are of the ſame kind with Eaſt and Weſt Dyals; Only whereas Eaſt and Weſt Dyals have but the Hour lines of half the longeſt Day deſcribed on them, theſe have all the Hour-lines of the whole Day; and are marked on both ſides the Noon line: as in the following Figure.

The

The *Style* of this Dyal muſt ſtand over the Noon line, Parallel to the Plane; for then it will alſo be Parallel to the Axis of the World: and its height above



the Plane muſt be the diſtance between the Center *i* of the Semi-Circle, and the point in the Contingent line cut by the Noon line. But I have inſerted the Figure, which alone is ſufficient Inſtructions.

PROB. LXIX.

To make Erect North Dyals, declining Eaſtwards, or Weſtwards.

DRaw on your Plane an Horizontal line, and on it deſcribe a Semi-Circle, as you were taught in *Prob.* 26.

Then rectifie the Sphere and Hour-Index, as by *Prob.* 5. And bring the Meridian to the Solſticial Colure, and one of the Vertical Circles to the Degree of Declination from the North point on the Horizon, and

the other Vertical Circle to the oppoſite Degree of the Horizon; for then the Vertical Circles ſhall repreſent a Plane declining from the North Eaſtwards, or Weſtwards accordingly. Then turn the Sphere Weſtwards, till the Index of the Hour-Circle points to all the Hours before Noon, and examine in what number of Degrees from the Zenith the Colure cuts the Vertical Circle, when the Index points to each Hour; For a line drawn from the Center A through the ſame number of Degrees reckoned from the Perpendicular A B, which is the XII a clock line towards C on the Plane, ſhall be the ſame Hour-lines the Index points at.

The Afternoon Hour-lines are found by bringing the Meridian again to the Colure, and turning the Earth Eaſtwards till ſo much of the Vertical Circle as is above the Horizon goes off the Colure; for then as the Index of the Hour-Circle points to the Afternoon Hours, the Colure ſhall on the Vertical Circle ſhew at what number of Degrees on your Plane, each reſpective Hour-line muſt ſtand.

Example.

I would make an Erect Dyal, declining from the North towards the Eaſt 63 deg. The Horizon and Hour-Index rectified, as before, I bring the Meridian to the Solſticial Colure, and one Vertical Circle to 63 degrees counted from the North Eaſtwards, and the other Vertical Circle to 63 deg. counted from the South Weſtwards. Then

I turn the Earth Weſtwards, till the Index points to	11	a clock, or till the Meridian paſs through 15 deg. of the Equator, and find the Colure cut the Vertical Circle in	9. 43	counted from the Zenith.
	10		19. 0	
	9		25.57	
	8		35.10	
	7		45.56	
	6		60.15	
	5		79.45	

And theſe are the diſtances of the Forenoon Hour-lines, which I ſeek in the Weſt ſide of the Plane, *viz.* from B towards C; and through theſe diſtances I draw lines from the Center, and theſe lines ſhall be the Forenoon Hour-lines.

For finding the Afternoon Hour-lines, I bring the Meridian again to the Colure, and then

turn the Earth Eaſtwards till the Index points to	1	a clock, or till the meridian paſs through 15 deg. of the Equator, and you ſhall find the Colure cut the Vertical Circle in	11.20	counted from the Zenith.
	2		26.47	
	3		49.20	
	4		75.52	

And theſe are the diſtances of the Afternoon Hour-lines; which diſtances I ſeek in the Eaſt ſide of the Plane, *viz.* from B towards D (as before) and ſo drawing lines from the Center A through theſe diſtances, I have all the Afternoon Hour-lines alſo drawn on my Plane.

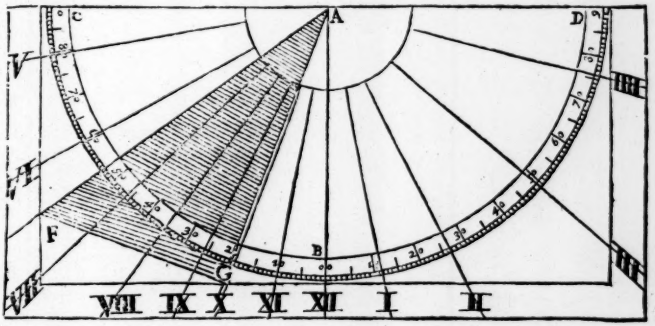
You may note, that this Plane is capable to receive no more Hour-lines after Noon than four; for when the Colure goes off the Vertical Circle above the Horizon, the Sun goes off theſe kind of Planes.

To theſe Hour-lines I ſet their numbers, as you may ſee in the Figure.

Then to find both the diſtances of the *Subſtilar line* from the XII a clock line, and the Elevation of the

Style above the Plane: Keep the Vertical Circles ſtill in their Poſition, and bring the number of Degrees of the Planes Declination, counted in the Horizon from the South point towards the Eaſt point, ſo ſhall the Vertical Circle and the Colure cut each other at right Angles; and the number of Degrees comprehended between the Colure and the Zenith in the Vertical Circle, ſhall be the number of Degrees between the *Subſtilar line* and the XII a clock line, which in this *Example* is 19 deg. 45 min. And the number of degrees comprehended between the Vertical Circle and the Pole, counted in the Colure, ſhall be the number of degrees that the *Style* is to be elevated above the Plane; which in this *Example* is 33 deg. 40 min. Wherefore for the diſtance of the *Subſtylar line* from the XII a clock line, I count in the Circle from the XII a clock line in the contrary ſide of the Plane, *viz.* in the Weſt ſide (becauſe the Plane declines towards the Eaſt) 19 deg. 45 min. as at D, and through that number of degrees and minutes from the Center A, I draw the line A G, which ſhall be the *Subſtilar line*: And from the *Subſtylar line* (either way) I number 33 deg. 40 min. the Elevation of the *Style* above the Plane, and through thoſe degrees and minutes I draw from the Center A, the line A F for the *Style* or *Gnomon*; Then I let fall the Perpendicular F G upon the *Subſtyle* A G: So is there a Triangle made; which if it be erected Perpendicularly upon the *Subſtyle* A G, the *Style* A F ſhall be parallel to the Axis of the World, and caſt a ſhadow upon the Hour of the Day.

Here



Here you may ſee that in Declining Dyals, the *Style* doth not ſtand at the ſame Elevation above the Plane that it doth in Erect Direct Dyals; neither doth it ſtand over the 12 a clock line; but ſwerves from it towards the Quarter of Declination.

PROB. LXX.

To make a South Erect Dyal, declining Eaſtwards, or Weſtwards.

AS in *Prob.* 65. an Erect Direct North Dyal hath the ſame Delineation that an Erect Direct South Dyal hath, and differs only in the placing the Figures of the Hour-lines; So a South Erect Dyal that Declines Eaſtwards, or Weſtwards, differs from a North Erect Dyal that Declines Eaſtwards, or Weſtwards, the ſame number of Degrees, only in placing the Hour-lines at the ſame diſtance on the contrary ſide of the Plane, and by tranſpoſing the Figures of 11 for 1; 10 for 2; 9 for 3, *&c.*

Thus, If you draw upon Glaſs, Horn, or an Oyled Paper, the North Dyal declining Eaſtwards, as in the foregoing *Probleme*, and place it to its due ſcituation, the back-ſide of it ſhall be a South Dyal declining towards the Weſt ſo many Degrees as the foreſide declines towards the Eaſt; and the only difference in it, will be the Figures of the Hour-lines; as was ſaid before.

PROB. LXXI.

To make Direct Reclining, or Inclining Dyals.

DIrect Reclining or Inclining Dyals, are the ſame with Erect Direct Dyals that are made for the Latitude of ſome other Places: The Latitude of which Places are either more than the Latitude of your own Place, if the Plane Recline, or leſs if the Plane Incline; and that in ſuch a proportion as the Arch of Reclination or Inclination of your Plane is.

Thus a Direct South Dyal Reclining 10 degrees in *Londons* Latitude, *viz.* $51\frac{1}{2}$ degrees, is an Erect Direct Dyal made for the Latitude of $61\frac{1}{2}$ degrees: And a Direct South Dyal Inclining 10 degrees in the Latitude $51\frac{1}{2}$ degrees, is an Erect Direct Dyal in the Latitude of $41\frac{1}{2}$ degrees: and is to be made according to the Directions in *Prob.* 64.

PROB.

Prob. LXXII.

To make Declining Reclining Dyals.

FOr the making of Dyals on Reclining or Inclining Planes, you muſt provide a *Gnomonical* Semi-Circle, which is a Semi-Circle equal to half the Equinoctial, and divided into 90 degrees from the middle of it either way, with 10, 20, 30, to 90. This *Gnomonical* Semi-Circle is ſo to be placed on the Sphere, as that it may lie in that great Circle of Heaven wherein your Inclining or Reclining Plane lies; for then, as it doth by the motion of the Earth paſs through the Solſticial Colure, the Solſticial Colure ſhall on it cut the number of degrees that the ſeveral Hour-lines muſt be drawn through on a Semi-Circle of Degrees.

Example.

Here at *London* I would make a Dyal on a Plane, Declining from the South Eaſtwards 30 degrees, and Reclining from the Zenith 20 degrees; *Londons* Latitude is $51\frac{1}{2}$ deg. Therefore having deſcribed on a Plane a Semi-Circle, as aforeſaid, I rectifie the Horizon and Hour-Index, as by *Prob.* 5. and bring the Vertical Circle to 30 degrees of the Horizon from the North Weſtwards, and the *Gnomonical* Semi-Circle to 20 degrees on the Vertical Circle counted from the Zenith; yet ſo as one end of the Semi-Circle may lie on 30 degrees from the Eaſt Northwards, and the other end on 30 degrees from the Weſt Southwards;

So

So ſhall the Sun in the Sphere (when the Sphere is rectified as by *Prob.* 5.) aſpect the Plane of the *Gnomonical* Semi-Circle, even as the Sun in Heaven doth a Plane Declining and Reclining as aforeſaid.

Having thus poſited the *Gnomonical* Semi-Circle, I find 11 deg. 10 min. comprehended between the Vertical Circle and the Meridian on the *Gnomonical* Semi-Circle, which ſhews that the twelve a clock line muſt ſtand 11 deg. 10 min. from the perpendicular line on the Dyal Plane, *viz.* from B towards C: Then I bring the Meridian to the Solſticial Colure, and to know the Forenoon Hour-lines

I turn the Earth Weſtwards till the Index points to	11	a clock, or till the Meridian paſs through 15 deg. of the Equator, and find the Colure cut the *Gnomonical* Semi-Circle in	15. 8	counted from the middle of the *Gnomonical* Semi-Circle.
	10		18.56	
	9		22.37	
	8		26.52	
	7		32.37	
	6		42. 5	
	5		62.43	

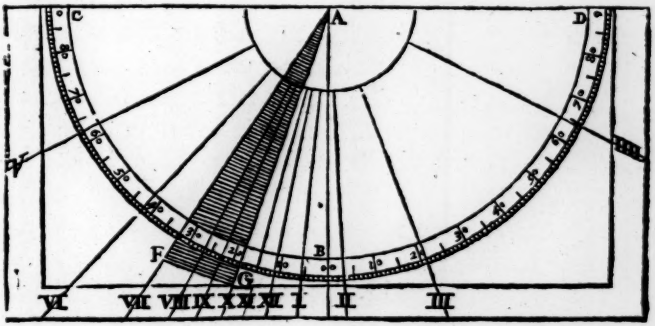
And theſe are the diſtances of the Forenoon Hour-lines; to which diſtances you may ſet Pricks on the Weſt ſide the Semi-Circle of the Plane, *viz.* from B to C.

The Afternoon Hour-lines are found by bringing the Colure again to the Meridian, for then

turning the Earth Eaſtwards till the Index points to	1	a clock, or till the Meridian paſs through 15 deg. of the Equator, I find the Colure cut the Gnomonical Semi-Circle in,	5. 45	counted from the middle of the *Gnomonical Semi-Circle.*
	–			
	2		2. 54	
	3		20.52	
	4		64.36	

And theſe are the diſtances of the Afternoon Hour-lines, and muſt all but the 1 a clock Hour-line be prickt

prick down at their reſpective diſtances on the Eaſt ſide the Plane, *viz.* from B to D: But becauſe the middle of the *Gnomonical* Semi-Circle comes not to the Colure before the Meridian paſſes through the firſt 15 degrees of the Equator; therefore the 1 a clock muſt ſtand ſo many degrees from the middle of the Semi-Circle on your Plane, as it wants of the middle of the *Gnomonical* Semi-Circle; which in this *Example* is 5 degrees 45 minutes on the Weſt ſide of the Plane: And for this cauſe I made a diſtinction with a line between the 1 a clock and the 2 a clock in the



foregoing Table. Then I draw lines from the Center A through every one of theſe pricks in the Semi-Circle, and they ſhall be the Hour-lines of this Declining Reclining Plane.

Having drawn the Hour-lines, I bring the other Vertical Circle to the Degree of the Planes Declination, *viz.* to 30 degrees from the South Eaſtwards; but I let the *Gnomonical* Semi-Circle ſtand as it did; And turning about the Earth till the Degrees of Reclination, *viz.* 20 degrees counted from the Horizon upwards come to the Solſticial Colure, I find 18 deg.

40. min of the *Gnomonical* Semi-Circle contained between the firſt Vertical Circle and the Colure, which is the diſtance of the *Subſtile* from the Perpendicular; And I alſo find 13 deg. 49 min. on the Colure contained between the *Gnomonical* Semi-Circle and the Pole, which is the Heighth that the *Style* muſt be raiſed over the *Subſtile*; Therefore I prick off in the Semi-Circle on the Plane the diſtance of the *Subſtyle* 18 deg. 40 min. from the Perpendicular Weſtwards, becauſe the Plane declines Eaſtwards, and from the Center A, I draw through that prick the line A E, which ſhall be the *Subſtyle*, and from this *Subſtyle* (either way) I count in the Semi-Circle on the Plane 13 deg. 49 min. and there make a Prick; Then from the Center A I draw through that Prick the line A F, to repreſent the *Style* or *Gnomon*: Then I let fall the Perpendicular F G upon the *Suſtile* A G; So is a Triangle made; which if it be erected Perpendicularly upon the *Subſtyle* A G, the *Style* A F ſhall be Parallel to the Axis of the World, and caſt a ſhadow upon the Hour of the Day.

Having made this Dyal, you have made four ſeveral Dyals, whereof this is one: And his oppoſite, *viz.* North declining Weſtwards 30 degrees, Inclining to the Horizon 70 degrees is another. The South declining Weſtwards 30 degrees, Reclining from the Zenith 20 degrees, is another: And its oppoſite, *viz.* North Decinling Eaſtwards 30 degrees, Inclining to the Horizon 70 degrees, is the other.

PROB.

PROB. LXXIII.

To make a Dyal upon a Declining Inclining Plane.

THe Precepts for making theſe Dyals, are delivered in the foregoing *Probleme:* Therefore we ſhall at firſt come to an *Example.*

I would make a Dyal upon a Plane in *Londons* Latitude Declining from the South Weſtwards 25 degrees, and Inclining towards the Horizon by the ſpace of an Arch containing 14 degrees. Having firſt deſcribed on the Plane a Semi-Circle, as was directed *Prob.* 64. I rectifie the Horizon and Hour-Index, as by *Prob.* 5. and bring the Vertical Circle to the degree of the Planes Declination, *viz.* to 25 degrees counted from the South Weſtwards, and the middle of the *Gnomonical* Semi-Circle to the degree of the Planes Inclination towards the Horizon from the Zenith, *viz.* to 25 degrees on the Vertical Circle counted from the Zenith, and the ends of the *Gnomonical* Semi-Circle to the degrees of Azimuth in the Horizon between which the Plane lies, *viz.* to 25 degrees counted from the Eaſt Southwards, and 25 degrees counted from the Weſt Northwards.

Then counting the number of degrees on the *Gnomonical* Semi-Circle contained between the Vertical Circle and the Meridian, I find 5 degrees 30 minutes; Therefore I number in the Semi-Circle deſcribed on the Plane 5 degrees 30 minutes from the Perpendicular Weſtwards, *viz.* from B to C, and there place the

12 a clock line. For finding all the Forenoon Hour-distances, I bring the Meridian to the Solsticial Colure,

and turn the Earth Westwards till the Index points to	11	a clock, or till the Meridian pass through 15 deg. of the Equator, and find the Colure cut the Gnomonical Semi-Circle in	20. 5	counted from the middle of the Gnomonical Semi-Circle.
	10		36.57	
	9		56.24	
	8		76.31	

And these are the distances of all the Forenoon Hour-lines; to which several distances I make pricks on the West side the Semi-Circle on the Plane, *viz.* from B to C.

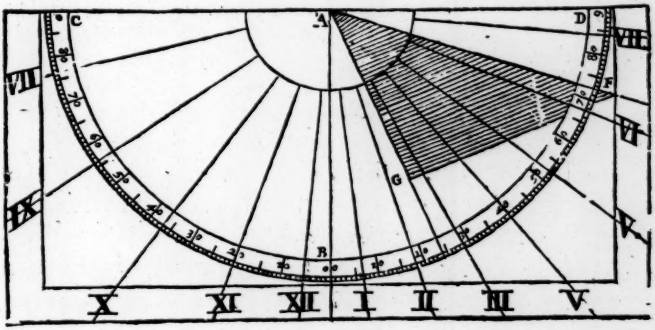
The Afternoon Hour-lines are found by bringing the Meridian again to the Colure; For then

turning the Earth Eastwards, till the Index points to	1	a clock; or till the Merid. pass through 15 deg. of the Equator, I find the Colure cut the *Gnomonical Semi-Circle* in	6. 20	counted from the middle of the *Gnomonical Semi-Circle.*
	2		18. 2	
	3		28.45	
	4		39.56	
	5		52.30	
	6		67.19	
	7		84.13	

And these are the distances of the Afternoon Hour-lines, which I also prick down at their respective distances from the Perpendicular Eastwards, *viz.* from B towards D on the Plane; and by drawing lines from the Center A through all the Pricks, I have all the Hour-lines that this Plane will admit of.

Having drawn the Hour-lines, I bring the other Vertical Circle to the Degree of the Planes Declination, *viz.* to 25 degrees of the Horizon from the North Eastwards, and count thereon 14 degrees (the Planes Inclination

Inclination towards the Horizon) from the Horizon upwards (but I keep the *Gnomonical* Semi-Circle in its former poſition) Then I bring theſe 14 degrees to the Solſticial Colure, and find 24 deg. 3 min. of the *Gnomonical* Semi-Circle contained between the Vertical Circle and the Colure for the diſtance of the *Subſtile*, and 48 deg. 5 min. (the diſtance of the *Gnomonical* Semi-Circle from the Pole on the Meridian) for the diſtance of the *Style* from the *Subſtyle*; Therefore I make a Prick on the Plane at 24 deg. 3 min. and through that Prick draw the line A G for the *Subſtyle*. At 48 deg. 5 min. diſtance from the *Subſtyle* I make another Prick, and through it draw the line A F for the diſtance of the *Style* from the *Subſtyle*; Then I let fall the Perpendicular F G upon the *Subſtyle* A G; So is there a Triangle made; which if it be erected



Perpendicularly upon the *Subſtyle* A G, the *Style* A F ſhall be parallel to the Axis of the World, and caſt a ſhadow upon the Hour of the Day.

Having made this Dyal, you have alſo four Dyals

made; as well as in the former *Probleme:* For this is one; and its oppoſite, *viz.* North Declining Eaſtwards 25 degrees, Reclining 76 degrees is another; The South Declining Eaſtwards 25 degrees, Inclining 14 degrees is another; and its oppoſite, *viz.* North Declining Weſtwards 25 degrees, Reclining 76 degrees is another.

PROB. LXXIV.

To find in what Place of the Earth any manner of Plane that in your Habitation is not Horizontal, ſhall be Horizontal.

CONſider in what great Circle of Heaven your Plane lies, for the Poles of that Circle are the Poles of your Plane. 64.

Example.

1. If your Plane lie in the Horizon, the Zenith is its Pole, and by turning the *Probleme*, the Plane ſhall there become Erect, as by *Prob.* 64.

2. If your Plane be Erect North or South, then it lies in the Eaſt and Weſt Azimuth; and the contrary quarter of the Horizon, *viz.* the South Point if your Habitation be in North Latitude, or the North point if your Habitation be in South Latitude ſhall be its Pole; So that an Horizontal Dyal made to the Latitude on the Meridian thus cut by the Horizon, ſhall be a Dyal to that Plane.

3. If

3. If your Plane be Erect East or West, then it lies in the Plane of the Meridian, and the East and West points of the Horizon shall be its Poles: And because the East and West points of the Horizon lye alwayes in the Equinoctial, as by turning about the Earth you may perceive, Therefore an Erect East or West Plane, shall in the Equinoctial be an Horizontal Plane.

4. If your Plane be Erect, and Decline East or West, it lies not then in the East and West Azimuth, but wants so much of that Azimuth as the Plane wants of the East or West point. Thus a Plane here at *London* Declining from the North 63 degrees towards the East, wants 27 degrees of the Eastern Azimuth, and consequently 27 degrees of Western Azimuth; And therefore its Poles must lie in 27 degrees from the South point of the Horizon Eastwards; as demonstratively will appear if you set the Vertical Circles so as to represent this Plane. Having thus considered in what Point of the Horizon the Poles of this Plane lies, Bring that point (*viz.* 27 from the South Eastwards) on the Horizon to the Solsticial Colure, and with Black-lead make a mark thereat on the Colure, then examine the Latitude of that mark (as by *Prob.* 26 you find the Declination of a Star) and you will find it 33 deg. 40 min. South; In which Latitude an Erect North Dyal Declining 63 degrees towards the East here at *London*, shall become an Horizontal Dyal.

5. If your Plane be a Declining Recliner or Incliner, then must it be represented by the *Gnomonical* Semi-Circle, as was shewed *Prob.* 72. And its Poles shall lie at 90 degrees distance from the point of Reclination

clination or Inclination on that Azimuth which cuts the middle of the Plane.

Example.

If here at *London* your Plane Decline from the South Eastwards 30 degrees, and Recline from the Zenith 20 degrees, Then shall the middle of your Plane lie in 30 degrees of Azimuth.

PROB. LXXV.

To make a Dyal on the Ceeling of a Room, where the Direct Beams of the Sun never come.

FInd some convenient place in the Transum of a Window to place a small round piece of Looking-Glass about the bigness of a Groat, or less, so as it may lie exactly Horizontal: The point in the middle of this Glass we will mark A, and for distinction sake call it *Nodus*: Through this *Nodus* you must draw a Meridian line on the Floar, thus; Hang a Plumb-line in the Window exactly over *Nodus*, and the shadow that that plumb-line casts on the Floar just at Noon will be a Meridian line: Having drawn the Meridian line on the Floar, find a Meridian line on the Ceeling, thus: Hold a plumb-line to the Ceeling, over that end of the Meridian line next the Window, If the Plumbet hang not exactly on the Meridian line on the Floar, remove your hand on the Ceeling one way or other as you see cause, till it do hang quietly

quietly juſt over it: and at the point where the plumb-line touches the Ceeling make a mark, as at B; that mark B ſhall be directly over the Meridian line on the Floar: then remove your plumb-line to the other end of the Meridian line on the Floar, and find a point on the Ceeling directly over it, as you did the former point, as at C, and through thoſe two points B and C on the Ceeling, ſtrain and ſtrike a black line with Small-Cole or any other Colour (as *Carpenters* do) and that line B C on the Ceeling ſhall be a Meridian line, as well as that on the Floar. Then examine the Meridional Altitude of the Equinoctial, as by *Prob.* 8. you did the Meridian Altitude of the Sun; and faſten a ſtring juſt on the *Nodus*, and remove that ſtring in the Meridian line on the Ceeling, till it have the ſame Elevation in a Quadrant that the Equinoctial hath in your Habitation; and through the point where the ſtring touches the Meridian line in the Ceeling, ſhall a line be drawn at right Angles with the Meridian, to repreſent the Equinoctial line. Thus in our Latitude the Elevation of the Equator being 38½ degrees, I remove the ſtring faſtned to the *Nodus* forwards or backwards in the Meridian line of the Ceeling, till the plumb-line of a Quadrant (when one of the ſides are applyed to a ſtring) falls upon 38½ degrees; and then I find it touch the Meridian line at D in the Ceeling: therefore at D I make a mark, and through this mark ſtrike the line D E (as before I did the Meridian line) to cut the Meridian line at Right Angles: This line ſhall be the Equinoctial line.

Then I place the Center of the Semi-Circle of Poſition upon the *Nodus*, and under-prop it ſo that the flat ſide of it may lie parallel to the ſtring when it is ſtrained between the *Nodus* and the Equinoctial, and

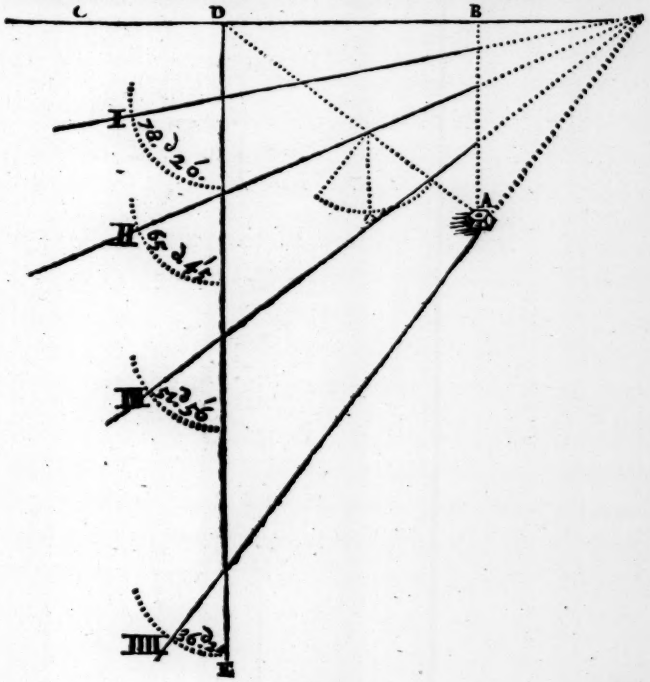
also so as the string may lie on the division of the Semi-Circle marked o when it is held up to the Meridian line in the Ceeling: Then removing the string the space of 15 degrees in the Circle of Position to the Eastwards, and extending it to the Equator on the Ceeling, where the string touches the Equator, there shall be a point through which the 1 a clock Hour-line shall be drawn: and removing the string yet 15 deg. further to the Eastwards in the Semi-Circle of Position, and extending it also to the Equator where it touches the Equator, there shall be a point through which the 2 a clock Hour-line shall be drawn. Removing the string yet 15 degrees further to the Eastwards in the Semi-Circle of Position, and extending it to the Equator, there shall be a point through which the 3 a clock Hour-line shall be drawn. The like for all the other Afternoon Hour-lines; so oft as the string is removed through 15 deg. on the Semi-Circle of Position, so oft shall it point out the Afternoon distances in the Meridian line on the Ceeling.

The scituation of the Semi-Circle of Position cannot conveniently be shewn in this Figure, unless it be drawn by the Rules of Perspective; Neither if it were, would it suit with the other demonstrations, except they were drawn by the same Rules also.

Having thus found out the Points in the Equator, through which the Afternoon Hour-lines are to be drawn, I may find the Forenoon Hour-distances also the same way, *viz.* by bringing the string to the several 15 degrees on the West side the Semi-Circle of Position, or else I need only measure the distances of each Hour-distance found in the Equator from the Meridian line on the Ceeling; for the same number of Hours from 12, have the same distance in the Equinoctial

noctial line on the other ſide the Meridian both before and after Noon. The 11 a clock Hour-diſtance is the ſame from the Meridian line with the 1 clock diſtance on the other ſide the Meridian: the 10 a clock diſtance the ſame with the 2 a clock diſtance: the 9 with the 3, *&c.* And thus the diſtances of all the Hour-lines are found out on the Equator.

Now if the Center of this Dyal lay within doors, you might draw lines from the Center through the pricks in the Equator, and thoſe lines ſhould be the Hour-lines, as in other Dyals: But the Center of this Dyal lies without Doors in the Air, and therefore not convenient for this purpoſe: So that for drawing the Hour-



lines, you muſt conſider what Angle every Hour-line in an Horizontal Dyal makes with the Meridian; that is, at what diſtance in degrees and minutes the Hour-lines of an Horizontal Dyal cut the Meridian; which you may examine as by *Prob.63.* for an Angle equal to the Complément of the ſame Angle, muſt each reſpective Hour-line make with the Equator on the Ceeling.

Thus upon the point markt for each Hour-diſtance in the Equinoctial line on the Ceeling, I deſcribe the Arches I, II, III, IIII, as in the Figure, and finding the diſtance from the Meridian of the Hour-lines of an Horizontal Dyal to be according to the third *Probleme.* Thus

The	1	a clock Hour-line	11.40	whoſe Complement to 90 is	78.20
	2		24.15		65.45
	3		38. 4		51.56
	4		53.36		36.24

I meaſure in a Quadrant of the ſame Radius with thoſe Arches already drawn from the Equinoctial line.

for the	1	a clock Hour	78.20
	2		65.45
	3		51.56
	4		36.24

and transfer theſe diſtances to the Arches drawn on the Ceeling: for then ſtraight lines drawn through the mark in the Arch, and through the mark in the Equator,

tor, and prolonged both wayes to a convenient length, ſhall be the ſeveral Hour-lines (aforeſaid) And when the Sun ſhines upon the Glaſs at *Nodus*, its Beams ſhall reflect upon the Hour of the day.

PROB. LXXVI.

The Legs of a Right Angled Spherical Triangle given, To find the Hypothenuſa and the two other Angles.

I Have in the *Uſe of the Globes* explained the Parts and Kinds of Spherical Triangles, and delivered ſuch *Theorems* as are introductive to their Solution; Therefore ſuppoſing them already learnt, I come directly to the Operation; only note that the Baſe of a Right Angled Spherical Triangle, ſhall in this following Treatiſe be alwayes placed on the Solſticial Colure, the Perpendicular on the Equator, the Hypothenuſa on the Vertical Circle, and the Angle at the Baſe ſhall be meaſured in an Arch of the Horizon.

Elevate the Horizon 90 degrees, ſo ſhall the Equinoctial and Vertical Circles be in the Zenith. Then count from the Equinoctial on the Solſticial Colure the number of degrees the Baſe contains, and there make a prick: Then count in the Equinoctial from the Solſticial Colure the number of degrees the Perpendicular contains, and make there a ſecond prick: Bring the Brazen Meridian to that prick, So ſhall the Solſticial Colure be ſeparated from the Brazen Meridian by the quantity of an Arch equal to the meaſure of the

Perpendicular: Then bring the Vertical Circle to the prick made in the Solſticial Colure; ſo ſhall the Triangle be repreſented on the Sphere. The Baſe ſhall lye on the Solſticial Colure between the Equinoctial and the Vertical Circle, the Perpendicular in the Equinoctial between the Solſticial Colure and the Brazen Meridian, and the *Hypothenuſa* on the Vertical Circle between the Zenith and the Solſticial Colure: and the number of degrees between each of theſe reſpective Arches, ſhall be the meaſure of each reſpeſpective ſide; for the Angles, The Right Angle is alwayes 90 degrees, the meaſure of the Angle at the Perpendicular, is numbred between the Eaſt point in the Horizon and the Vertical Circle: But to find the Angle at the Baſe you muſt turn the Triangle, making the Perpendicular Baſe, and the Baſe Perpendicular.

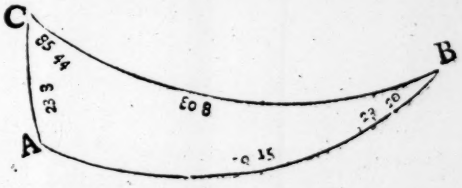
Example.

Having the two Legs given, A B 79 degrees 15 minutes, and C A 23 degrees 8 minutes, I would find the meaſure of the *Hypothenuſa* C B, and the Angles B C.

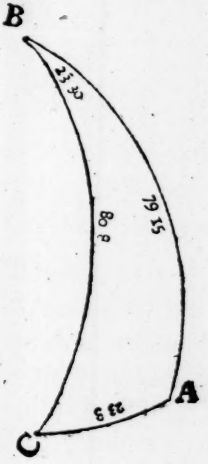
The Horizon elevated, as before, I make A B Baſe, and C A Perpendicular, counting on the Solſticial Colure from the Equinoctial 79 degrees 15 minutes, and there I make a Prick: Then I number in the Equinoctial from the Solſticial Colure 23 degrees 8 minutes, the length of the Perpendicular; and there I make a ſecond prick: To this prick I bring the brazen Meridian; So is the Solſticial Colure ſeparated from the Brazen Meridian ſo many degrees and minutes as is the length of the Perpendicular C A. Then I

move

move the Vertical Circle till the edge of it touch the Prick made in the Solſticial Colure; So ſhall the number of degrees and minutes of the Vertical Circle comprehended between the Solſticial Colure and the Zenith be the meaſure of the *Hypothenuſa* C B; which in this *Example* is 80 degrees 8 minutes: The number of degrees in the Horizon comprehended between the Equinoctial and the Vertical Circle of the Angle C, 85 degrees 44 minutes: the Angle A is a right Angle, 90 degrees: And to find the Angle B, turn the Triangle, thus: As before A B was Baſe, ſo now make C A Baſe; and as before A C was Perpendicular, B A ſhall be Perpendicular: ſo is the Triangle turned.



Now, as before I counted 79 degrees 15 minutes from the Equinoctial on the Solſticial Colure, which was the length of that Baſe, ſo now I count 23 degrees 8 minutes on the Solſticial Colure, which is the length of this Baſe, and there I make a prick: and as before I counted 23 degrees 8 minutes on the Equinoctial from



the

the Solſticial Colure, which was the length of that Perpendicular, ſo now I count 79 degrees 15 minutes on the Equinoctial, which is the length of this Perpendicular; and there I make a prick on the Equinoctial, Then I bring the brazen Meridian to this prick (as before) So ſhall the Solſticial Colure be diſtant (as before) from the brazen Meridian ſo many degrees and minutes as is the length of this Perpendicular, *viz.* 79 degrees 15 minutes: Then I bring the Vertical Circle to the Prick made on the Solſticial Colure at 23 degrees 8 minutes diſtant from the Equinoctial; ſo is the Triangle turned: And ſo ſhall the Arch of the Horizon comprehended between the Equinoctial and the Vertical Circle be the meaſure of the Angle B 23 degrees 30 minutes. You alſo ſee again the meaſure of the *Hypothenuſa* B C 80 degrees 8 minutes on the Vertical Circle counted between the Zenith and the Solſticial Colure.

PROB. LXXVII.

A Leg and the Hypothenuſa given, To find the reſt.

Example.

THe Leg given ſhall be C A in the former Triangle 23 degrees 8 minutes, the *Hypothenuſa* C B 80 degrees 8 minutes. The Horizon elevated as by the laſt *Probleme*, number the Leg C A 23 degrees 8 minutes on the Equinoctial from the Solſticial Colure, and there make a prick; Bring the brazen Meridian

to

to this prick; then number on the Vertical Circle the *Hypothenuſa* B C 80 degrees 8 minutes from the Zenith towards the Horizon, and make there on the edge of the Vertical Circle another prick; Then move the Vertical Circle till the Prick made on the edge of it come to the Solſticial Colure; ſo ſhall the Triangle be made: The Arch of the Equinoctial comprehended between the Solſticial Colure and the brazen Meridian, ſhall repreſent A C the Perpendicular: The Arch of the Vertical Circle comprehended between the Zenith and the Solſticial Colure, ſhall repreſent B C the *Hypothenuſa*; and the Arch of the Solſticial Colure comprehended between the Equinoctial and the Vertical Circle, ſhall repreſent B A the Baſe; which was one Leg ſought, and is (as you will find) 79 degrees 15 minutes: The Angle C you will find in the Horizon 85 degrees 44 minutes; The Angle A is the Right Angle 90 degrees; and to find the Angle B you muſt turn the Triangle, as you were directed in the former *Probleme*.

PROB. LXXVIII.

The Hypothenuſa and an Angle given, To find the reſt.

THe *Hypothenuſa* given ſhall be B C of the Triangle in *Prob.*76. 80 degrees 8 minutes, the Angle given ſhall be C 85 degrees 44 minutes: The Horizon rectified as by *Prob.*76. Count the given-Angle 85 degrees 44 minutes on the Horizon from the Equinoctial, and there place the Vertical Circle: Then

turn about the Earth till 80 degrees 8 minutes of the Vertical Circle counted from the Zenith downwards come to the Solſticial Colure, ſo ſhall the Triangle be made on the Sphere. The Arch of the Equator comprehended between the Solſticial Colure and the brazen Meridian ſhall ſhew the length of the Perpendicular C A 23 degrees 8 minutes: The Arch of the Solſticial Colure comprehended between the Equinoctial and the Vertical Circle ſhall ſhew the length of the Baſe A B 79 degrees 15 minutes: The Right Angle made at the Interſection of the brazen Meridian with the Equinoctial is 90 degrees: And to find the meaſure of the Angle B, you muſt turn the Triangle, as you were directed *Prob.* 76.

PROB. LXXIX.

A Leg and the Angle adjoyning given, To find the reſt.

IN the Triangle of *Prob.* 76. The Leg given ſhall be C A 23 degrees 8 minutes, the Angle adjoyning ſhall be C 85 degrees 44 minutes. The Horizon rectified as by *Prob.* 76. I turn about the Earth till the Solſticial Colure be diſtant from the brazen Meridian 23 degrees 8 minutes the length of the Leg C A: Then I count on the Horizon from the Equinoctial 85 degrees 44 minutes, the meaſure of the Angle C; ſo is the Triangle made on the Sphere. The Arch of the Solſticial Colure comprehended between the Vertical Circle and the Equinoctial ſhall ſhew the length of the Baſe A B 79 degrees 15 minutes: The Arch of the Vertical

Vertical Circle comprehended between the Zenith and the Solſticial Colure ſhall ſhew the length of the *Hypothenuſa* C B 80 degrees 8 minutes : The Right Angle made at the Interſection of the Equinoctial and the brazen Meridian is 90 degrees : And to find the meaſure of the Angle B, you muſt turn the Triangle, as you were directed *Prob.* 76.

PROB. LXXX.

A Leg and the Angle oppoſite given, To find the reſt.

IN the Triangle of *Prob.* 76. the Leg given ſhall be A B 79 degrees 15 minutes, the Angle oppoſite ſhall be C 85 degrees 44 minutes. The Horizon rectified as by *Prob.* 76. I bring the Vertical Circle to 85 degrees 15 minutes of the Horizon, the meaſure of the Angle C: Then I turn the Earth till the Vertical Circle come to 79 degrees 15 minutes of the Solſticial Colure (which is the meaſure of the Leg A B) ſo is the Triangle made on the Sphere. The Arch of the Equinoctial comprehended between the Solſticial Colure and the brazen Meridian ſhews the length of the Leg C A 23 degrees 8 minutes : The Arch of the Vertical Circle comprehended between the Zenith and the Solſticial Colure ſhall ſhew the length of the *Hypothenuſa* C B 80 degrees 8 minutes : The Right Angle made at the Interſection of the Equinoctial and the brazen Meridian, is 90 degrees : And to find the meaſure of the Angle B, you muſt turn the Triangle, as you were directed in *Prob.* 76.

PROB. LXXXI.

The Angle given, To find the Sides.

IN this caſe you muſt turn the Angles into Sides, making an Oblique Triangle on the Sphere, whoſe Sides ſhall be equal to the given-Angles: So ſhall the Angles of this Triangle found, be the meaſure of the Sides required.

Example.

In the Triangle of *Prob.* 76. the Angle A is 90 degrees, the Angle B 23 degrees 30 minutes, the Angle C 85 degrees 44 minutes. The Horizon Rectified as by *Prob.* 76. I ſet the Right Angle A 90 degrees on the brazen Meridian between the Pole and the Equinoctial; For the Angle B I number from the Zenith on the Vertical Circle 23 degrees 30 minutes, which ſhall be the ſide repreſenting that Angle: For the Angle C I number on the Solſticial Colure from the Pole of the Earth towards the Equinoctial 85 degrees 44 minutes, which ſhall be the Side repreſenting that Angle. Then I turn the Earth and move the Vertical Circle till I can joyn the 23 degrees 30 minutes counted before on the Vertical Circle and this 85 degrees 44 minutes counted on the Solſticial Colure together; So is a Triangle made on the Sphere, whoſe ſide being equal to the Angles given, ſhall have its Angles equal to the Sides required. Thus the Arch of the Equinoctial comprehended between the Solſtici-

al

al Colure and the brazen Meridian ſhall be found 23 degrees 8 minutes, the meaſure of the ſide A C: The Arch of the Horizon contained between the neareſt Pole and the Vertical Circle ſhall be found 79 degrees 15 minutes, the meaſure of the ſide B A: And to find the Hypotenuſa B C, you have now *Data*'s enough, either to find it as by ſome of the former *Problemes*; or elſe you may find it by turning the Triangle, as by *Prob.* 76.

Of Oblique Triangles.

PROB. LXXXII.

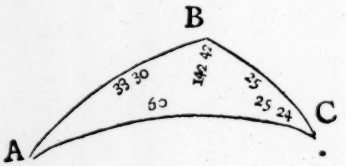
The three Sides given, To find the Angles.

SEt the Horizon above the Equinoctial on the Meridian, the ſpace of an Arch, equal to one of the given-Sides, ſo ſhall that given-Side be comprehended between the Pole and the Zenith: Then count from the Pole upon the Solſticial Colure the meaſure of the ſecond Side, and there make a prick; Count alſo from the Zenith on the Vertical Circle downwards the meaſure of the third ſide, and make there on the edge of the Vertical Circle another prick; Then turn the Earth and Vertical Circle till you can joyn theſe two pricks together; So ſhall your Triangle be made on the Sphere: And then the number of degrees of the Equinoctial comprehended between the Solſticial Co-

lure and the brazen Meridian ſhall be the meaſure of the Angle at the Pole: The Arch of the Horizon comprehended between the Vertical Circle and the interſection of the brazen Meridian with the Horizon on that ſide the Pole is elevated ſhall be the meaſure of the ſecond Angle. And for finding the third Angle, you muſt turn the Triangle as by *Prob.* 76.

Example.

In the Triangle A B C annexed, The Side A B contains 38 degrees 30 minutes, the ſide B C 25 degrees, and the ſide A C 60 degrees; I would meaſure theſe Angles. I place one of theſe ſides upon the brazen Meridian *viz.* A B 38 deg. 30 minutes: the Complement of 38 deg. 30 min. is 51 degrees 30 minutes; therefore I elevate the Pole 51 degrees 30 minutes above the Horizon, ſo ſhall the Zenith be diſtant from the Pole 38 degrees 30 minutes, and count downwards on the Vertical Circle the meaſure of the ſide B C 25 degrees, and there I make a prick: Then from the Pole I count on the Solſticial Colure 60 degrees, the meaſure of the ſide A C, and there I make another prick: Then I move the Earth and Vertical Circle backwards or forwards, till theſe two pricks are joyned together; So ſhall the Triangle A B C be made on the Sphere: The Arch of the brazen Meridian comprehended between the Pole and Zenith ſhall repreſent the ſide A B; The



The Arch of the Vertical Circle comprehended between the Solſticial Colure and the brazen Meridian ſhall repreſent the ſide B C; and the Arch of the Solſticial Colure comprehended between the Pole and the Vertical Circle ſhall repreſent the ſide A C; The Pole ſhall repreſent the Angle A; the Zenith the Angle B; and the interſection of the Solſticial Colure with the Vertical Circle ſhall repreſent the Angle C. The Angle at the Pole is meaſured in the Equator; for the Degrees comprehended between the Solſticial Colure and the brazen Meridian being 17 degrees 15 minutes ſhews 17 degrees 15 minutes to be the meaſure of the Angle A: The Angle at the Zenith is meaſured in the Horizon; for the degrees comprehended between the Interſection of the brazen Meridian with the Horizon on that ſide the Pole is elevated being 142 degrees 42 minutes, ſhews that 142 degrees 42 minutes is the meaſure of the Angle B. Thus two Angles are found; the third is wanting: which I find thus.

I turn the Triangle, placing either A or C in the Zenith.

Example.

I place A at the Zenith, which before was at the Pole; ſo ſhall C be at the Pole, and B at the Interſection of the Solſticial Colure and Vertical Circle, and the ſide A C ſhall be comprehended between the Pole and the Zenith: The ſide A C contains 60 degrees; its Complement to 90. is 30 degrees; therefore I ſet the Horizon 30 degrees below the Pole; ſo ſhall 60 degrees be in the Zenith: Then I count on the Vertical Circle from the Zenith downwards the

the meaſure of the other ſide, *viz.* 38 degrees 30 minutes, and there I make a prick: and from the Pole on the Solſticial Colure I count the meaſure of the laſt ſide, *viz.* 25 degrees, and there I make another prick: Then I move the Earth and Vertical Circle (as before) till theſe two pricks joyn, ſo is the Triangle altered on the Sphere; for the Arch of the brazen Meridian comprehended between the Pole and Zenith, which before was 38 degrees 30 minutes, is now 60 degrees; the Arch of the Vertical Circle comprehended between the Solſticial Colure and the brazen Meridian, which before was 25 degrees, is now 38 degrees 30 minutes; and the Arch of the Solſticial Colure comprehended between the Vertical Circle and the Pole, which before was 60 degrees, is now 25 degrees. Thus the Angle C being now at the Pole, its meaſure is found in the Equinoctial, *viz.* that Arch comprehended between the Solſticial Colure and the brazen Meridian; which is 25 degrees 24 minutes; and the meaſure of the Angle A, which is now in the Zenith, having its ſides, the one an Arch of the brazen Meridian, the other an Azimuth, (or which is all one) an Arch of the Vertical Circle is meaſured in the Horizon, as all Azimuths are, and found 17 degrees 15 minutes, as before.

PROB.

PROB. LXXXIII.

Two Sides and the Angle contained between them given, To find the reſt.

Example.

IN the former Triangle I have given the ſides A B, 38 degrees 30 minutes, A C 60 degrees, and the Angle A 17 degrees 15 minutes.

I elevate the Pole 51 degrees 30 minutes; So ſhall the Zenith be diſtant from the Pole 38 degrees 30 minutes, the meaſure of the ſide A B: The other ſide is 60 degrees: This 60 degrees I count from the Pole on the Solſticial Colure, and there I make a prick: The Angle given is 17 degrees 15 minutes: This I count in the Equinoctial from the Solſticial Colure, and to this degree and minute in the Equinoctial I bring the brazen Meridian; So ſhall the Solſticial Colure be ſeparated from the brazen Meridian 17 degrees 15 minutes: Then I bring the ſide of the Vertical Circle to the prick made on the Solſticial Colure; So ſhall the Triangle be made on the Sphere.

Then to find the unknown ſide B C, I count the number of degrees on the Vertical Circle comprehended between the Zenith and the Solſticial Colure, and find 25 degrees, which is the meaſure of the ſide B C. To find the meaſure of the Angle B, I count the number of degrees contained between the Interſection of the Meridian with the Horizon from that ſide the Pole is Elevated, and the Vertical Circle, and

find 142 degrees 42 minutes, which is the measure of the Angle B: And to find the Angle C, I turn the Triangle, as in *Prob.* 76.

PROB. LXXXIIII.

Two Sides and an Angle oppoſite to one of them given, To find the reſt.

Example.

IN the Triangle in *Prob.* 82. the Sides given are A B 38 degrees 30 minutes, and A C 60 degrees: The Angle given oppoſite to A C is B 142 degrees 42 minutes: I elevate the Pole to the Complement of one of the given-ſides; ſuppoſe A B, which being 38 degrees 30 minutes, its Complement to 90 deg. is 51 deg. 30 min. So is the Zenith diſtant from the Pole 38 deg. 30. min. Then I bring the Vertical Circle to 142 degrees 42 minutes (the meaſure of the given-Angle) counted from the Interſection of the Meridian with the Horizon on that ſide the Pole is Elevated: Then I count on the Solſticial Colure from the Pole the meaſure of the ſide A C 60 degrees, and there I make a prick; And laſtly turn about the Earth till the edge of the Vertical Circle come to the prick; So is the Triangle made on the Sphere. The degrees of the Vertical Circle comprehended between the Solſticial Colure and the Zenith, being 25 degrees, is the meaſure of the ſide B C: The degrees of the Equinoctial comprehended between the Solſticial Colure and the brazen Meridian, being 17 degrees 15 minutes, is the meaſure

measure of the Angle A. And for finding the measure of the Angle C, I turn the Triangle, as in *Probleme* 76.

PROB. LXXXV.

Two Angles and the Side comprehended between them given, To find the reſt.

Example.

IN the Triangle of *Prob.*82. the Angles given are A 17 degrees 15 minutes, and B 142 degrees 42 minutes, the Side comprehended between them is A B 38 degrees 30 minutes; I ſet the Zenith 38½ degrees diſtant from the Pole, and count on the Horizon from the Interſection of the Meridian with the Horizon on that ſide the Pole is elevated the meaſure of the given-Angle B, *viz.* 142 deg. 42 min. and to this number of degrees and minutes of the Horizon, I bring the edge of the Vertical Circle; then I turn the Earth till the brazen Meridian is diſtant from the Solſticial Colure 17 degrees 15 minutes of the Equinoctial, which is the meaſure of the other given-Angle; So ſhall the Triangle be made on the Sphere; and the Arch of the Vertical Circle comprehended between the Solſticial Colure and the Zenith ſhall be the meaſure of the ſide B C 25 degrees, and the Arch of the Solſticial Colure comprehended between the Pole and its Interſection with the Vertical Circle ſhall be the meaſure of the ſide A C 60 degrees. The meaſure of the Angle C is found by turning the Triangle, as in *Prob.*76.

Prob. LXXXVI.

Two Angles and a Side oppoſite to one of them given, To find the reſt.

Example.

IN the Triangle of *Prob.* 82. the Angles given are A 17 degrees 15 minutes, and B 142 degrees 42 minutes; the Side given is B C 25 degrees, being the ſide oppoſite to the Angle A; the Angle A is made at the Pole of the Earth, and meaſured in the Equator: Therefore I ſeparate the brazen Meridian from the Solſticial Colure 17 degrees 15 minutes on the Equinoctial; So doth the Pole repreſent the Angle A. The Angle B is made at the Zenith, and meaſured in the Horizon: Therefore I count on the Horizon 142 deg. 42 min. and there I make a prick; to this prick I bring the edge of the Vertical Circle (not minding what degree of the Meridian I make the Zenith) Then I count from the upper end of the Vertical Circle 25 degrees downwards, the meaſure of the ſide B C, and there I make a prick, and keeping the Vertical Circle to the prick made on the Horizon, I ſlide the upper end of it forwards or backwards till the prick on the Vertical Circle come to the Solſticial Colure; So ſhall the Triangle be made on the Sphere: Then the Arch of the brazen Meridian comprehended between the Pole and the upper end of the Vertical Circle, ſhall be the meaſure of the ſide A B 38 degrees 30 minutes; and the Arch of the Solſticial Colure comprehended between

between the prick on the Vertical Circle, and the Pole ſhall be the meaſure of the ſide A C 60 degrees.

But the Angle C you muſt find by turning the Triangle, as in *Prob.* 76.

PROB. LXXXVII.

Three Angles given, To find the Sides.

THis Triangle is taught to be reſolved by Mr. *Palmer* on the *Planiſphere, Book* 3. *Chap.* 19.

It is to be known (ſaith he) *that if you go to the Poles of the three great Circles whereof your Triangle is made, theſe Poles ſhall be the Angular Points of a ſecond Triangle; and the two leſſer ſides of this ſecond Triangle, ſhall be equal to the two leſſer Angles of your firſt Triangle: The greateſt ſide of the ſecond Triangle ſhall be the Supplement of the greateſt Angle of the firſt Triangle* (*that is, ſhall have as many degrees and minutes as the greateſt Angle of the firſt Triangle wanted of* 180 *degrees.*) See *Ptiſcus Trigonometry, Lib.* 1. *Prop.* 61.

This ſecond Triangle therefore (all whoſe Sides are known from the Angles of the firſt) you ſhall reſolve by *Prob.* 82. and having by that *Probleme* found "the Angles of this ſecond Triangle, know that the "two leſſer Angles of the ſecond Triangle, ſhall be ſe- "veral and reſpectively equal to the two leſſer ſides "of the firſt Triangle (and the leaſt Angle to the leaſt "ſide, the middle Angle to the middle ſide) and the "greateſt Angle of this ſecond Triangle being ſub- "tracted out of 180 degrees, ſhall leave you the "greateſt ſide of your firſt Triangle.

Example.

If the Angles given be 142 degrees 42 minutes, 17 degrees 15 minutes, and 25 degrees 24 minutes; and the ſides be enquired. Draw by aim a rude Scheam of this firſt Triangle, writing in the Angle A 17 degrees 15 minutes, in B 142 degrees 42 minutes, in C 25 degrees 24 minutes, ſuppoſing the ſides yet unknown: then draw under this by aim alſo a Scheam of the ſecond Triangle, ſetting his Baſe parrallel with the Baſe of the firſt Triangle, and making the Baſe of the ſecond ſhorter than the Baſe of the firſt. Set alſo B at the Vertical Angle, and A C at the Baſe; as in the firſt Triangle.

Then ſay,

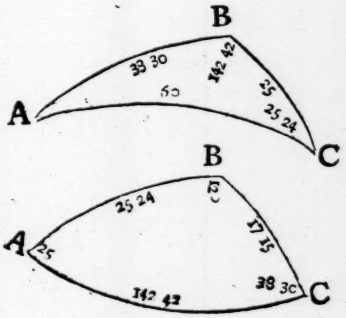
Becauſe A in the firſt Triangle is 17 degrees 15 minutes; therefore in the ſecond Triangle B C (which ſubtendeth A) ſhall be 17 degrees 15 minutes: and becauſe C in the firſt Triangle is 25 degrees 24 minutes, therefore in the ſecond Triangle the ſide A B (which ſubtendeth C) ſhall be 25 degrees 24 minutes; and becauſe B the greateſt Angle in the firſt Triangle, is 142 deg. 42 minutes; therefore in the ſecond Triangle, the ſide A C (which ſubtendeth B) ſhall be the Complement thereof to 180 degrees, *viz.* 37 deg. 18 minutes: Write now upon the ſides of this ſecond Triangle, the quantities of the ſides, ſo is your ſecond Triangle ready to be reſolved, as by *Prob.* 82. Whereby you ſhall find the Angles of the ſecond Triangle, as I have expreſſed them in the Scheam. A 25 degrees, C 38 degrees 30 minutes, B 120 degrees.

Now

Now laſtly, I ſay theſe Angles of the ſecond Triangle thus found, give me the ſides of the firſt Triangle; which I ſeek in this manner.

In the ſecond Triangle.		In the firſt Triangle.
A is 25 degrees.		B C is 25 degrees.
C is 38. 30.	Therefore	A B 38. 30.
B is 120. 00.		A C 60. 00. Complement

of 120 deg. to 180. And thus by all the Angles given, we have found out all the ſides; which was required.



Having then the Angles of your firſt Triangle given, and its ſides now found, you ſhall find its ſcituation on the Sphere thus: Place (as in *Prob.* 82.) A B 38 degrees 30 minutes on the brazen Meridian between the Pole and the Zenith, and ſeparate the brazen Meridian from the Solſticial Colure 17 degrees 15 minutes of the Equinoctial, A C 60 degrees on the Solſticial Colure, B C 25 degrees on the Vertical Circle counted from the Zenith when it is applyed to 142 dgerees 42 minutes of the Horizon: you ſhall ſay, Becauſe the Eaſt point of the Horizon is the Pole of the Arch A B, therefore at the Eaſt point of the Horizon ſhall ſtand the Angle C, which A B ſubtendeth: Then number from the Vertical Circle on the Horizon Eaſtwards 90 degrees; and

and there is the Pole of the Arch B C: Therefore there ſhall ſtand the Angle A, which B C ſubtendeth. Then count in the Equator from the firſt Meridian 90 degrees, which will end in the Autumnal Solſtice, and there make a prick; for there is the Pole of the Arch or Side A C. Therefore at that prick ſhall ſtand the Angle B, which A C ſubtendeth.

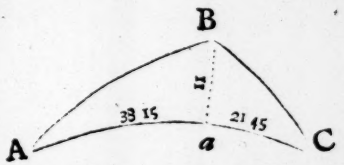
Here you ſee your ſecond Triangle made by the Poles of the firſt: Only the Side A B is wanting: To get that, bring one of the Circles of Longitude to that point in the Horizon you found the Pole of the Arch B C to lie in, *viz.* to 37 deg. 18 min. beyond the Eaſt point Northwards, and at that point on the Horizon make a prick on the Circle of Longitude; Then move the Earth and Vertical Circle to or fro till that prick and the prick made before for the Angle B, are bo that once cut by the Side of the Vertical Circle, and you will find 25 degrees 24 minutes of the Vertical Circle comprehended between the two pricks, for the meaſure of the ſide A B.

PROB. LXXXVIII.

How to let fall a Perpendicular that ſhall divide any Oblique Spherical Triangle into two Right Angled Spherical Triangles.

IN the Oblique Triangle of the former *Problemes*, there is given the ſides A B 38½ degrees, and B C 25 degrees, and the Angle C 25 degrees 24 minutes. It is required to let fall a Perpendicular B *a* from

from the Angle B, upon the Baſe A C; and to know both the meaſure of this Perpendicular, and the parts it divides the Baſe into.



Therefore Elevate the Pole above the Horizon ſo much as is the meaſure of the Angle C, which in this *Example* is 25 degrees 24 minutes, and bring the Eaſt point of the Horizon to the Interſection of the Solſticial Colure with the Equinoctial; ſo ſhall the Angle at the Eaſt point of the Horizon comprehended between the Horizon and the Solſticial Colure, be equal to the Angle C: then count in the Solſticial Colure from the Eaſt point of the Horizon the meaſure of the ſide B C 25 degrees, and bring the graduated edge of the Vertical Circle to theſe 25 degrees; ſo ſhall the Arch of the Horizon comprehended between the Eaſt point and the Vertical Circle be the number of degrees that the Perpendicular falls upon the Baſe, counted from the Angle C to *a*, which in this *Example* is $21\frac{3}{4}$ degrees, and the Arch of the Vertical Circle comprehended between the Horizon and the Solſticial Colure, is the meaſure of the Perpendicular B *a* 11 degrees.

And thus by letting fall this Perpendicular you have two Right angled Spherical Triangles made, the one B *a* C, wherein is found C *a*, $21\frac{3}{4}$ degrees, B C 25 degrees, B *a* 11 degrees, C 25 degrees 24 minutes, and *a* the Right angle: there remains only the Angle B unknown; which you muſt find by turning the Triangle, as was taught *Prob.* 76. The other Right angled Spherical Triangle made, is B *a* A, wherein is found A *a*

(Complement to $21\frac{1}{4}$ degrees to 60 degrees (the whole Base before given) $38\frac{1}{4}$ degrees, A B 38 degrees 30 minutes, B *a* 11 degrees, and *a* the Right angle; which is more than enough to find the Angle A and B.

FINIS.

THese SPHERES, both *General* & *Particular*; *Ptolomaick Spheres*; GLOBES, *Celestial* and *Terrestrial* of all sizes; MAPS for all Countries; SEA-PLATS for all Navigations; The *Mathematical Jewel*; The *Spiral-Line*, and most other Projections, Are made and Sold by the Author, *Joseph Moxon*, at his Shop on *Ludgate-hill* near *Fleet-Bridge*, at the sign of *Atlas*: Where you may have Books for the use of them; with other Mathematical Books, and Instruments. *&c.*

The

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MVSEVM BRITANNICVM